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VOLUME II

A STUDY OF NUCLEAR RADIATION EFFECTS ON TELEMETRY

VOLUME II — NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

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BY

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FOREWORD

This report was prepared by LTV Vought Aeronautics Division of Ling-Temco-Vought, Inc., Dallas, Texas, under Contract Number AF 33(657)-11646, Project Number 4107, Task Number 410721. The contract effort was administered under the cognizance of the Electronic Warfare Division (AVW), AF Avionics Laboratory (AFAL), AFSC, Wright-Patterson Air Force Base, Ohio. Project monitor for the effort was Mr. Kenneth W. Foulke (AVWC).

This report consists of two volumes.

ABSTRACT - VOLUME II

Approximately 1500 nuclear radiation effects "Design Allowables" on electronic materials and parts were compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. The radiation effects Design Allowable is a nuclear radiation environmental exposure under which the associated material or part is expected to exhibit certain specified characteristic changes. The information presented does not include all available data, but is felt to be representative of the current nuclear radiation effects state-of-technology. This data should serve as an aid in performing nuclear radiation effects analyses of currently available telemetry systems and provide useful inputs for hardening such systems for use in a nuclear radiation environment.

This technical documentary report has been reviewed and is approved.

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1.0 INTRODUCTION

The radiation effects information presented in this Volume was compiled to provide a useful working tool for designing nuclear radiation tolerant telemetry systems. Most of the data was taken from the 92 different reports listed in the references. Inconsistencies in experimental conditions, variations in test objectives, and different methods of reporting test data make it impossible to give equal credence to each entry in the following tables. This should not detract from the usefulness of such tables, however, if the designer recognizes this fact and takes it into account in formulating his design goals. The information presented herein will suffice to select nuclear radiation tolerant materials and parts to be used in a wide range of nuclear environments.

This data, entitled nuclear radiation effects Design Allowables, is presented in a form that will give the designer a summary of extracted data on the behavior, stability and capabilities of components and materials operating in a nuclear radiation environment without having to examine in detail numerous documents containing the results of irradiation tests on these components and materials. The term "Radiation Effects Design Allowable" is defined as the nuclear radiation environmental exposure under which the associated material or component is expected to exhibit certain specified characteristic changes. These specific characteristic changes are presented as the basis for the "Design Allowable." This information cannot be interpreted as specific parameter variations for other materials or components made by the same or different manufacturers unless an accurate evaluation establishes the similarity of the two items. Material formulation, processing, quality control, fabrication techniques, parameter utilization, and environmental test conditions all have pertinent bearing on the data presented in these tables, hence, care must be exercised in its application.

Although both steady-state (Section 2.0) and pulse (Section 3.0) radiation effects information is contained in this document, the major effort (about 90 percent) has been devoted to the steady-state effects. This represents a logical division based on the availability of useful information and the nature of the respective problems. The steady-state data readily lends itself to the tabular presentation used here and should be most useful for designing nuclear radiation tolerant telemetry systems. The nature of pulse radiation effects and the lack of good experimental pulse data on parts make this type of presentation extremely difficult to compile and use. However, when Section 3.0 is used in conjunction with the information presented in Section 2.0 of Volume I, it should serve a very useful purpose in giving the designer a feel for the primary pulse effects problems, the general type of experimental work which has been conducted, and sufficient source references to obtain additional information as required.

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The information contained herein does not include all available data but is representative of the current nuclear radiation effects state-of-technology. Ninety-two documents were selected from a total of 800 reviewed. From the 92 documents 1500 radiation effects "Design Allowables" have been extracted, analyzed, compiled, and presented in a tabular form in this Volume. In general, the tables contain a description of the material or part, the nuclear radiation exposure to which it was tested, the specific changes observed, and the source reference (Figure 1). The following paragraphs further describe the specific information contained in the tables and discuss the general guidelines which were used in extracting and presenting the data.

Components and materials are categorized under their general classification. Specific identification, such as manufacturer, part numbers, functional rating values, element composition, basic use and other identifying remarks, are called out to the extent that this information is available in the referenced reports. Also, whenever known, the number of items irradiated are given. Manufacturers are listed in alphabetical order under the specified material or component. Under each manufacturer, the materials are listed in alphabetical order and the components are listed in ascending functional rating value. The exceptions to these two types of listings are crystals and electron tubes which are listed in ascending numerical order by part number identification. Materials and components for which the manufacturer is unknown are listed within the section under the heading of Miscellaneous.

The "Design Allowables" are presented as previously defined. Selective "characteristic changes" observed during the irradiation and the corresponding nuclear radiation levels at which they occurred are presented as the basis for the Design Allowables. If no defined exposure is given in this column, the percentage changes were assumed to refer to the total exposures presented in the "Design Allowable" columns. In most cases these changes are expressed in the percentage of change from the pretest value.

The exposure data presented in the "Design Allowable" Tables are based on the definitions given below:

Nomenclature	Symbol	Definition
Thermal Neutrons	n_t	Neutrons whose energy are above .025 ev. ($E > .025$ ev)
Epicadmium Neutrons	n_e	Neutrons whose energy is above the cadmium cutoff, approximately 0.4 ev. ($E > .4$ ev)
Fast Neutrons	n_f	Neutrons with energies greater than 0.01 Mev. ($E > .01$ Mev)

Nomenclature	Symbol	Definition
Neutron Flux	n/cm^2-sec or n ϕ	The number of neutrons passing through an imaginary sphere of one cm^2 cross-sectional area in one sec.
Neutron Exposure or Time Integrated Flux	n/cm^2 or nvt	The total number of neutrons passing through an imaginary sphere of one cm^2 cross-sectional area in a specified time t.
Gamma Dose Rate	ergs/gm-(C)-sec	The energy, in ergs, which would be absorbed from the gamma field by a gram of carbon per second.
Gamma Exposure Dose	ergs/gm-(C)	Gamma dose rate times time.
Proton Exposure	P/cm^2	The total number of protons passing through an imaginary sphere of one cm^2 cross-sectional area in a specified time t.

For converting gamma exposures reported in roentgens to ergs/gm-(C), a nominal conversion factor of 100 was used. In recording all nuclear radiation exposures only one decimal place accuracy was used.

The Radiation Effects Reference Number refers to the source of information as listed in the references, Section 4.0, and the respective pages from which this data was extracted. These references may be consulted for more detailed information if required.

Additional information on the general effects of nuclear radiation on numerous materials and components, certain criteria for designing nuclear radiation tolerant telemetry systems, and specific examples of the use of these tables in establishing the nuclear radiation effects state-of-technology on telemetry systems are contained in Volume I.

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

Column		Contents
MATERIAL OR COMPONENT — General Classification of Material, Component		Component Identification - Manufacturer, component value, type or part number and number of items tested. The two exceptions are the electron tubes and crystals which are listed in numerical order followed by the manufacturer and number tested. i.e., Aerovox Corp. 100 pf ±20%, C-80 - V101AM (Cerafil) (2 ea) i.e., 2D21W/5727 Thyratron-Xenon Gas GE (3 ea) RCA (3 ea)
DESIGN ALLOWABLES	$\frac{\text{ergs}}{\text{gm-(C)}}$	Gamma Radiation Exposure Dose in ergs/gm-Carbon. This represents the total exposure dose that the article received during the test. i.e., 1(X) (X denotes power of ten)
	$\frac{n}{cm^2}$	Time Integrated Neutron Flux (n/cm^2) with the neutron energy (E) given when known. This represents the maximum time integrated flux to which the article was exposed in the test. i.e., 1(X) (X denotes power of ten) (E > Y Mev) ne = epicadmium neutrons (E > .4 ev) nt = thermal neutrons nf = fast neutrons of unknown energies
BASIS FOR DESIGN ALLOWABLES		Selective "characteristic changes" observed during the irradiation and the corresponding nuclear radiation levels at which they occurred are presented here. If no exposure is given, the percentage changes refer to the total doses presented in the Design Allowable columns. i.e., Resistance (-5%) @ 2.1(15)nf
RADIATION EFFECTS REFERENCE No.		Radiation Effects References as given in Bibliography, Section 4.0. i.e., AA p. BB, CC-DD AA - Document Reference No., p. - page BB, CC-DD - pages on which information was obtained

FIGURE 1 FORMAT FOR PRESENTING NUCLEAR RADIATION EFFECTS TEST DATA

1.0 INTRODUCTION

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2.1 **BATTERIES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Batteries	ergs/gm (C)	n/cm²		
Eagle-Richer				
GAP-4019 12v or 28v 5A, Silver-zinc (3ea)	2.6(10)	8.6(15) (E>1 Mev)	No effect on the operation of 2 of these batteries. The output of the remaining battery was cut-off. A small increase in neutron & gamma exposure may cause batteries of this type to fail.	34 p20
EAP-6034, 28v Thermal battery (6 ea)	2(10)	1.5(16) (E>1 Mev)	No effects on battery operation	34p20
#6062 Thermal Battery (2 ea)	2.7(10)	3.7(16) (E>.3Mev)	No damage	31p 376-82
#767A, 14.5v Lifetime 1500 watt-min. Silver Oxide-zinc (2 ea)	2.7(10)	3.7(16) (E>.3Mev)	-75% Capacity	31p 376-82
Rechargeable Silver Oxide-zinc cell (1ea)	2.7(10)	3.7 (16) (E>.3Mev)	Inconclusive	31p 376-82

2.2 **CAPACITORS**

2.2.1 CERAMIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Ceramic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm²		
Allen-Bradley Co.				
220pf ± 10%, 500VDC C16-2211 Epoxy Sealed	2.8(10)	1.3 (15)nf 1.1 (15)ne	Capacitance(-11.2%) at 1.29(14)nf	4p142
	2.6 (9)	7.8 (15)nf (E>0.5Mev)	Capacitance(-3.2%)	4p142
Aerovox Corp.				
45pf CC25CH4505(4 ea)	2.9 (10)	1.0 (15)ne	Capacitance(-0.6%) at 7.1(14)ne	1p84, 87, 685
100pf ± 20% C-80-V101AM(Cerafil) (2 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.9%) at 8.58(15)nf	12p213
1500pf CK60Y3212(4 ea)	2.4 (10)	7.4 (14)ne	Capacitance(-13.2%) at 3.7(14)ne	1p127, 685
1720pf CK27W1522(4 ea)	2.6 (10)	4.3(14)ne	Capacitance(-6.5%) at 2.88(14)ne	1p105, 685
2000pf CK61Y1522(4 ea)	2.4 (10)	5.5 (14)ne	Capacitance(-25.5%) at 4.33(14)nf	1p135, 685
5200pf CK37W4722(4 ea)	2.0 (10)	1.9 (14)ne	Capacitance(-13%) at 1.9(14)ne	1p121-125, 685
0.1mf ± 20% CR-90 Mil-C-11015A	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.9%) at 1.65(16)nf	12p208
0.25mf ± 20% C[illegible] Mil-C-11015A(1 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.9%) at 1.3(16)nf	12p207

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Ceramic	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Centralab Division				
45pf CC25CH450J(4 ea)	2.9 (10)	1.0 (15)ne	Capacitance (-10%) at 4.18(14)ne	1p84,685
1500pf CK60Y[illegible]21Z(4 ea)	2.4 (10)	7.4 (14)ne	Capacitance (-16.5%) at 4.95(14)ne	1p127,685
2000pf CK61Y152Z(4 ea)	2.4 (10)	5.5 (14)ne	Capacitance (-16.5%) at 4.33(14)ne	1p135,685
2300pf CK27W152Z(4 ea)	2.6 (10)	4.3(14)ne	Capacitance (-4.3%) at 3.58(14)ne	1p105,685
5000pf CK3[illegible]W472Z(4 ea)	2.0 (10)	1.9 (14)ne	Capacitance (-5.5%) at 1.3(14)ne	1p121-125,685
6200pf, +80% to -20%. Type CE or CF(1 ea	7.1 (10)	4.7 (16) (E > 1 Mev)	Leakage R(-99.9%) at 1.45(16)nf	12p217
0.02mf, +80% to -30%, D.F. 2%, DDA-104(1 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.8%) at 3.58(15)nf	12p215
0.1mf, +80% to -30% DDA-104, T5-V(1 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.6%) at 3.58(15)nf	12p216
0.47mf, [illegible] to -20% DA 10-474 (1 ea)	7.5 (10)	3.9 (16) (E > 1 Mev)	Leakage R(+16.9%) at 2.13(16)nf	12p219
Cornell-Dubilier Electric Corp.				
40pf CD-White (1 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.3%) at 3.58(15)nf	12p209
0.001mf ± 40% CD (Black) (2 ea)	6.2 (10)	4.2 (16) (E > 1 Mev)	Leakage R(-99.9%) at 3.58(15)nf	12p211

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitor, Ceramic	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Erie Resistor Corp.				
45pf CC25CH450J(4 ea)	2.9 (10)	1.0 (15)ne	Capacitance (-0.4%) at 8.63(14)ne	1p84,685
1500pf CK60Y821Z(4 ea)	2.4 (10)	7.4 (14)ne	Capacitance (-11.5%) at 5.85(14)ne	1p127,685
2000pf CK61Y152Z(4 ea)	2.4 (10)	5.5 (14)ne	Capacitance (-14%) at 4.5(14)ne	1p135,685
2300pf CK27W152Z(4 ea)	2.6 (10)	4.3(14)ne	Capacitance (-9%) at 2.88(14)ne	1p105,685
5200pf CK37W472Z(4 ea)	2.0 (10)	1.9 (14)ne	Capacitance (-5.5%) at 1.3(14)ne	1p121-125,685
Litton Systems, Inc.				
500pf $BaTiO_3$ Wafer(2 ea)		1.5(16) (E>2.9 Mev)	Leakage R(-88.5%) at 4.59(15)nf	11p29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Ceramic	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Onondaga Pottery Co.				
1000pf @200% (Temp. Sensitive) Type CH, Hi K	6 (9)	2.1 (16)nf (E>0.5Mev)	Capacitance (-24.6%) @ 2 (16) nf	4p100,133
"	4.1 (10)	2.4 (14)nf (E>0.5Mev)	Capacitance (-44%) at 1(13)nf	4p100,133
Sprague Products Co.				
4700pf, +80% to -20% 600VDC, Ceramic Disc (1 ea)	7.1 (10)	4.7 (16) (E>1 Mev)	Leakage R(-99.9%) at 9.54(15)nf	12p218
" (1 ea)	6.2 (10)	4.2 (16) (E>1 Mev)	Leakage R(-99.9%) at 1.65(16)nf	12p210

2.2 CAPACITORS

2.2.2 ELECTROLYTIC

2.2.2.1 Aluminum

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (AL)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Bell Telephone Labs, Inc.				
0.3mf, 35VDC Experimental (3 ea)		2.6(17)nf	Capacitance (+65%) at 2(16)nf	16p167
3mf, 35VDC Experimental (3 ea)		2.6(17)nf	Capacitance (-20%) 1 failure	16p167

2.2 CAPACITORS

2.2.2 ELECTROLYTIC

2.2.2.2 Columbium

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (Columbium)	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Fansteel Metallurgical Co.				
17mf, 10VDC with Teflon Spacer, 41037-1	6.3(10)	1.6(16) (E>0.5Mev)	Capacitance (-10%)	35p 10.18-25
17mf, 10VDC 41037-2	6.3(10)	1.6(16) (E>0.5Mev)	Capacitance (-10%)	35p 10.18-25

2.2 **CAPACITORS**

2.2.2 **ELECTROLYTIC**

2.2.2.3 **Tantalum**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (Tantalum)	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Astron Corp.				
1.0mf ± 20%, dissipation 6%, TES-1M-25-20 Mil-C-26655(USAF) (100 ea)	9.0 (10	2.1 (16) (E>2.9Mev)	Capacitance-92 ea were out of tolerance. No catastrophic failures. Tolerance threshold is 5.15(13) nf > 2.9 Mev & 1.475(8) ergs/gm-(C)	45p11
Fansteel Metallurgical Corp.				
20mf, 35V STA377(Teflon Spacer) (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	2 Failed 6.2(15)nf Capacitance (-1%)	35p 10.10-17
20mf, 35V STA377(modified)(12ea)	6.4(10)	1.6(16) (E>0.5Mev)	2 Failed 6.2(15)nf	35p 10.10-17
70mf, 10V STA357 (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	All good No failures	35p 10.10-17
General Electric Co.				
75mf, 30VDC (Foil) (Minuteman) (2 ea)		1.5(16) (E>0.1Mev)	Capacitance (-9.35%) at 3.8(13)nf	32 Fig. 23
75mf, 30VDC (Foil) (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p118

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (Tantalum)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm²		
General Electric (Cont'd)				
1000mf 50VDC Wet Slug, Hermetically Sealed, 200D180-6113 (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance (+6.6%) at 1.3(6)ergs/gm-(C) & 1(13)nf	53 Fig 29
ITT				
100mf 20VDC Solid Tant. Hermetically Sealed (1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+4%)	10p118
100mf, 20VDC, Solid, HS (1 ea)		6.5(15) (E>0.1Mev)	Capacitance (+11.5%)	32 Fig. 23
Kemet Co.				
5mf 50V K5H50D6 (11 ea)	6.4(10)	1.6(16) (E>0.5Mev)	1 failure at 4.4(15)nf	35p 10.10-17
1.2mf, ±10%, 60 VDC K1R2J60K, J Series (Solid)	7.6(9)	3.7 (15) (E > 1 Mev)	Leakage R(-97.8%) at 1.8(15)nf	12 p 201
15mf. 75VDC K15J75 (Solid Tant.) (9 ea)	1(9)	7 (15) (E>0.1Mev)	Capacitance (-30%) at 3(15)nf @ 150°C	10p 124

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (Tantalum)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Kemet Cont.				
15mf 75VDC @ 85°C K15J75 (10 ea)		1(16) (E>0.1Mev)	Capacitance (+11.2%)	53 Fig. 28
25mf, 45V K25H45 (30 ea)	1.3 (11)	4.3 (16) (E>0.5Mev)	8 failed < 1(16)nf 14 failed between 1(16) & 3.8(16)nf	35p 10.10-17
35mf @ 6V K35H6D5 (12 ea)	6.4(10)	1.6(16) (E>0.5Mev)	Leakage R(large decrease) 3 failed at < 1(16)nf	35p 10.10-17
Sprague Products Co.				
40mf, 50VDC, hermetically sealed, (foil) 143D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
40mf, 50VDC, H.S. (foil) 142D (2 ea)		1(16) (E>0.1Mev)	Capacitance (+17.5%) at 9(14)nf	32 Fig. 9 & 24
40mf, 50VDC, H.S. (foil) 143D (2 ea)		6(15) (E>0.1Mev)	Capacitance (+10%) at 9(14)nf	32 Fig. 9 & 24
75mf, 30VDC (Herm. Seal) Etched foil, 143D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
75mf, 30VDC, double seal, Foil tant., 222D (2 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (-4%)	10p 119
75mf, 30VDC, double seal, Tant. foil, 222D (2 ea)		1.5(16) (E>0.1Mev)	Capacitance (-9.3%)	32 Fig. 23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic (Tantalum)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
U. S. Semcor				
18mf, 100VDC Wet Tant. Slug(1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+21 %) at 5.5(15)nf	10p 119
47mf, 100VDC Wet Tant. Slug(1 ea)	1.5(9)	1(16) (E>0.1Mev)	Capacitance (+12%) at 9(15)nf	10p 119
47mf, 100VDC Wet Tant. Slug(1 ea)		1.5(15) (E>0.1Mev)	Capacitance (+38%)	32 Fig. 9 & 24
Western Electric Co.				
40mf, 35VDC, Solid Tant., Hermetically Sealed (4 ea)	5.6 (10)	2.4(17)nf	Capacitance (+5%) at 1(16)nf 2 failed	15p 21,22

2.2 **CAPACITORS**

2.2.3 GLASS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitor, Glass	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Corning Glass Works				
4.7pf ± 5%, 300VDC CY20C-472J Mil-C-112728	7.6(9)	3.7 (15) (E>1 Mev)	Leakage R(-78.4%) at 2.08(15)nf	12p 200
1200pf CY15C122J (6 ea)	3.1 (10)	1.1 (15)ne	Capacitance (+2.5%) at 2.34(14)ne	1p 253, 687
5100pf CY20C512J (6 ea)	3.1 (10)	1.1 (15)ne	Capacitance (+1.5%) at 1.36(14)ne	1p259, 687
0.02mf 200VDC (4 ea)	5.6 (10)	2.4(17)nf	Capacitance (+2%)	15p 17, 19
Vitramon, Inc.				
200pf, 500VDC CY13C201J-A (Vitreous Enamel)	7.3(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.5%) at 8.14(15)nf	4p 119
220pf, 300VDC CY13C221J-A (Vitreous Enamel)	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+2%) at 8(15)nf	4p 119
220pf, 500VDC (Vitreous Enamel) CY17C221J-A	7.3(9)	2.27(16)nf (E>0.5Mev)	Capacitance (+2%) at 1.09(16)nf	4p 119
560pf, 300VDC (Vitreous Enamel) CY1756lJ-A	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+1.6%) at 8(15)nf	4p 119
560pf, 500VDC (Vitreous Enamel) CY22C561J-A	2.8 (10)	1.4(14)nf (E>0.5Mev)	Capacitance (+0.4%) at 1.25(14)nf	4p 124

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Vitramon Cont.				
560pf, 500VDC (Vitreous Enamel) CY22C561J-A	6.0(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.6%) at 1.04(16)nf	4p 125
1200pf, 300VDC (Vitreous Enamel) CY22C122J-A	3.1 (10)	1.8 (14)nf (E>0.5Mev)	Capacitance (+0.4%) at 7.4(13)nf	4p 124
"	7.3(9)	2.2 (16)nf (E>0.5Mev)	Capacitance (+1.5%) at 4.3(15)nf	4p 125
1200pf, 500VDC (Vitreous Enamel) CY32C122J-A	5.3(9)	1.6 (16)nf (E>0.5Mev)	Capacitance (+2%) at 3.69(15)nf	4p 125
"	2.6 (10)	1.2 (14)nf (E>0.5Mev)	Capacitance (-0.5%) at 2.25(12)nf	4p 128
5600pf, 300VDC (Vitreous Enamel) CY32C562J-A	2.7 (10)	1.3 (14)nf (E>0.5Mev)	Capacitance (+1%)	4p 128

2.2 CAPACITORS

2.2.4 MICA

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs gm-(C)	$\frac{n}{cm^2}$		
Aerovox Corp.				
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14)ne	Capacitance (-1.5%) at 7.68(14)ne	1p 94, 685
6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (-5.5%) at 7.97(14)ne	1p 143, 686
" (6 ea)	1.7 (11)	1.1 (15)ne	Capacitance (-1%)	5p12
0.1mf CM65B104J (4 ea)	9.0 (10)	2.4 (15)ne	Capacitance (-5%)	5p17
Bendix Corp.				
0.12mf, 500VDC E-315, Hi-Temp "Samica" (6 ea)	1.3(9)	2.2(14) (E > 0.5Mev)	Capacitance (0.0%)	35p 10.34
Centralab				
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14) nf	Capacitance (+10.5%) at 3.82(14)nf	1p 94, 685

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Cornell-Dubilier Electrical Corp.				
6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (-0.26%) at 1.13(15)ne	1p 143, 686
0.1mf CM65C104J (6 ea)	3.4 (10)	1.1 (15)ne	Capacitance (-1.7%) at 1.05(15)ne	1p 174, 686
Erie Resistor Corp.				
100pf CB11PX681G (6 ea)	1.9 (10)	6.4 (14)ne	Capacitance (-3.5%) at 5.35(14)ne	1p 72, 685
200pf CC45CH201J (3 ea)	2.7 (10)	9.3(14)ne	Capacitance (-2%) at 7.68(14)ne	1 p 94, 685
680pf CB21FX101G (6 ea)	1.9 (10)	6.4 (14)ne	Capacitance (-1%) at 5.35(14)ne	1 p 78, 685

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm^2		
Micamold Radio.Corp.				
6200pf CM35B622J (4 ea)	3.5(10)	1.1 (15)ne	Capacitance (+0.26%) at 1.34(14)ne	1p 143, 686
Sprague Products Co.				
0.1mf CM65C104J (6 ea)	3.4 (10)	1.1 (15)ne	Capacitance (-2.2%) at 1.03(15)ne	1p 174, 686

2.2 CAPACITORS

2.2.5 MYLAR

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Capacitors, Mylar	ergs/gm-(C)	n/cm²		
Balco Research Labs				
0.5mf, 200vdc QTM-1(Zinc-Metalized Mylar) (6 ea)	4.3(10)	1.4(16) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
Cornell-Dubilier Electric Corp.				
0.25mf±20%, 400vdc STM (Miniroc) (6 ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%)	35p 10.25-33
0.25mf±20%, 400vdc MUF (6ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%)	35p 10.25-33
Electron Products Div. Preco, Inc.				
36500pf±5%, 200vdc Dry Mylar (3 ea)	1.5(9)	1(16) E>0.1Mev)	Capacitance(-15%) @ 4.5(15)nf	10p 118
0.047mf±20%, Diss.> 0.6%, Mylar film & foil, E-120 (1 ea)	6.2 (10)	4.2 (16) (E> 1Mev)	Leakage R(-99.7%) @ 1.65(16)nf	12p 205
0.1mf, 200vdc (Metalized Mylar) DG2-104(IS) (2 ea)	3.9 (8)		Leakage R(-90%) @ 2.8(6) ergs/gm-(C)	12p 183
" (1 ea)	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-94.6%)	12p 189

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Capacitors, Mylar	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Electron con't				
0.22mf @400vdc +20% Mylar film & foil E4-224(IS)	7.6(9)	3.7 (15) (E> 1Mev)	Leakage R(-96.1%) @ 7.5(13)nf	12p 203
0.22mf+20%, Diss<0.6% Mylar film E-120, E4-224 (1 ea)	6.2 (10)	4.2 (16) (E > 1Mev)	Leakage R(-98%) @ 8.58(15)nf	12p 204
0.68mf+1%, 200vdc Dry Mylar (3 ea)	1.5(9)	1(16) (E>.1Mev)	Capacitance(-7.3%) @ 9(15)nf	10p 118
Electronic Fabricators, Inc.				
0.5mf+10%, 200vdc Type MW Mylar	2.2(9)	5.6(14) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
General Electric Co.				
0.039mf, 300vdc Dry Impregnated CTM 393VDK, 2V104 (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance (<1%)	10p 122
0.039mf 300vdc Dry Impregnated CTM 393VDK,2V104 (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+3.62%)	53 Fig 29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Good-All Electric Manufacturing Co.				
2200pf±20%, 100vdc 663-UW	5.3(9)	1.6(16)ne	Capacitance(+9.2%) @ 5.4(15)ne	4p 112
" 200vdc			Capacitance(+10.4%) @ 8(15)ne	
" 400vdc			Capacitance(+8.5%) @ 8(15)ne	
" 600vdc			Capacitance(+14.3%) @ 1.01(15)ne	
0.047mf, 600vdc Dry Impregnated 663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(+2.28%)	53 Fig 29
0.047mf, 600vdc X663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-6%) @ 2(13)nf	10p 122
0.05 mf, 50 vdc Dry impregnated X601PE (446) (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-7.2%) @ 2(12)nf	10p 121
" (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-5.9%) at 2.4(15)nf	53 Fig. 29
0.1mf, 100vdc Dry Impregnated 613G (1049.1W2)(3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-9.3%) @ 1(13)nf	53 Fig. 29
" (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-1%)	10p 121

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors : Mylar	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Good-All con't				
0.1mf, 50vdc Dry Impregnated 627G (1049.5W2)(3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+9.8%) @ 2.4(15)nf &3.6(8) ergs/gm-(C)	53 Fig. 29
0.1mf, 50vdc Dry Impregnated X601PE (3ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-2.63%) @ 3.2(6)ergs/gm-(C), 2.1(15)nf	53 Fig. 29
0.1mf, 50vdc X601PE (446) (3ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-1%)	10p 121
0.15mf, 50vdc Liquid Impregnated 617G (1540-S) (3ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(+2.5%) @ 2(13)nf	10p 121
" (3ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(+3.1%) @ 7.6(14)nf	53 Fig. 29
0.22mf+10%, 300vdc BSAD-Γ 663 VW (6 ea)	1.1(10)	2.7(15) (E>0.5Mev)	Capacitance(-2%) Leakage R -1(3)	35p 10.26-33
0.3mf, 100vdc Dry Impregnated 663F (3 ea)	3.6(8)	2.4(15) (E>0.1Mev)	Capacitance(-2.3%) @ 2.4(15)nf	10p 121
" (3 ea)	4.6(8)	3.6(15) (E>0.1Mev)	Capacitance(-7.15%)	53 Fig. 29

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Capacitors, Mylar				
Hopkins EngineeringCo.				
0.1mf, 200vdc P-12M (Metalized Mylar)	1.9(10)	1.5(15) (E>2.9Mev)	Leakage R(-94.6%) @ 5.2(8) ergs/gm-(C)	12p 193
0.1mf @200vdc±20% P-12M(A03678-5) (film)	7.6(9)	3.8(15) (E>1Mev)	Leakage R(-80.8%) @ 4.2(9) ergs/gm-(C)	12p 197
0.12mf @200vdc±5% P-122MFC (film)	7.6(9)	3.8(15) (E>1Mev)	Leakage R(-82.3%) @ 1.0(9)ergs/gm-(C)	12p 199
Plastic Capacitors,Inc.				
0.01mf±20% Impregnated with Stycast #62 LS4-103 (9 ea)	1.6(11)	7.6(14)ne	Capacitance(+8.3%) immediately	2p 328
Sprague Products Co.				
1mf HYDREL MIL-C-26244 (100 ea)	9.1(10)	2.2(16) (E>2.9Mev)	Capacitance(small increase) 94ea failed Threshold of failure 1.845(15)nf> 2.9Mev & 8.495(9)ergs/gm-(C)	45p 11,19

2.2 CAPACITORS

2.2.6 MYLAR & PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar & Paper	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sangamo Electric Co.				
0.1mf, CPM08 impregnated with C16-18 alkyl biphenyl dielectric fluid(10ea)	1(10)		100% of all capacitors tested failed under a voltage pulse of 2000 volt @ 135°C after a dose of 8(8)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Bis(Phenoxphenyl) Ether Dielectric Fluid (10 ea)	1(10)		86% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C after a dose of 1(9)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with MONO ISOPROPYLBIPHENYL Dielectric Fluid (25 ea)	1(10)		65% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9)e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Etherm "A" dielectric fluid	1(9)		57% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p. 94 p. 10 p. 1
0.1mf, CPM08 impregnated with Etherm "A" Dielectric fluid with 4 % inhibitor (14 ea)	1(9)		50% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p. 96 p. 10 p. 1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar & Paper	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sangamo con't				
0.1mf, CPM08 impregnated with Bis(Phenoxyphenyl) Ether Dielectric Fluid (50 ea)	1(10)		8% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C after a dose of 1(9)	70 p 96,10,1
0.1mf, CPM08 impregnated with Mono IsopropylBiphenyl Dielectric Fluid without inhibitor	1(10)		62% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p 96,10,1
0.1mf, CPM08 impregnated with Mono IsopropylBiphenyl Dielectric Fluid with inhibitor	1(10)		30% of all capacitors tested failed under a voltage pulse of 2000-V @ 135°C after a dose of 1(9) e/g-C	70 p 96,10,1
0.1mf, CPM08 with Etherm "A" Dielectric Fluid	1(10)		10% of all capacitors tested failed under a voltage pulse of 2000vdc @ 135°C after a dose of 1(9) e/g-C	70 p 100,1,10
0.1mf, CPM08 impregnated with oversized inhibited FC-43 Dielectric fluid (Perfluorutributylamine) (8 ea)	1(10)		100% of all capacitors tested failed under a voltage pulse of 2000volts @ 135°C after a dose of 6.2(8) e/g-C	70 p 98,1,10

2.2 CAPACITORS

2.2.7 PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm^2		
Aerovox Corp.				
0.1mf + 20% CP04A1EE104M (3 ea)	3.3 (10)	2.7 (15)ne	Capacitance (-12.6%) at 6.24(14)ne	1 p 185
" (3 ea)	2.6 (10)	1.1 (15)ne	Capacitance (-20%)	2p 285, 286
0.1mf CP04A1KE104M (3 ea)	2.6 (10)	1.1 (15)ne	Capacitance (-11%) 1 shorted	2p 297
" (3 ea)	3.3 (10)	2.7 (15)ne	Capacitance (-14.5%) at 3.95(14)ne	1p 193, 686
0.1mf CP25A1EF104K (3 ea)	2.6 (10)	1.1 (15)ne	All failed 2 shorted, 1 rupture	2p 307
0.5mf CP53B2FF504K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-20.9%) at 6.25(14)ne	1p 219, 687
0.5mf CP53B1D504K (3 ea)	2.9 (10)	2.4 (15)ne	Capacitance (-32.3%) at 2.13(14)ne	1p 206, 687
" (3 ea)	4.6 (10)	3.0 (15)ne	Capacitance All 3 shorted out in pile, All had oil leaks at end of test	2 p 316
0.5mf CP53B1FF504K (3 ea)	4.6 (10)	7.2(15)ne	Capacitance (-16.5%) at 6.6(14)ne 2 shorted at 3.78 (15)ne	2p 319
1.0mf CP63B1EF105K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-28%) at 3.36(14)ne	1p 229, 687
10 mf CP70E1EF106K (3 ea)	2.7 (10)	1.3 (15)ne	Capacitance (-34.5%) at 3.19(14)ne	1p 240, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm^2		
Astron Corp.				
1.0 mf CP08A1KE105M Mil-C-25A (100 ea)	8.1(10)	1.8(16) (E > 2.9 Mev)	89 Failed Catastrophically. General capacitance decrease, 22-had exploded, 59-shorted. Threshold tolerance-1.04(14)nf >2.9 Mev & 3.92(8) ergs/gm-(C)	45 p. 11-17
Bendix Corp. Scintilla Div.				
0.1 mf E - 200 Impregnated with Polyester Resin	1(9)		10% of all capacitors tested failed under a voltage pulse of 2000 volts @ 135°C	70 p. 100
Chicago Condensor Corp.				
10 mf CP70E1EF106K (3 ea)	2.7 (10)	1.3 (15)nf	Capacitance (-37.6%)	1 p. 245, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Cornell-Dubilier Elect. Corp.				
0.1 mf CP04A1EE104M (3 ea)	2.6 (10)	1.1 (15) ne	Capacitance (-13.7%) @ 1.11(15)ne, 1 shorted	2 p. 285, 286
0.1 mf CP04A1EE104M (3 ea)	3.3 (10)	2.7 (15) ne	Capacitance (-12.6%) @ 6.23(14) ne	1 p. 185, 686
0.1 mf CP04A1KE104M (3 ea)	3.3 (10)	2.7 (15) ne	Capacitance (+16.2%) @ 2.58 (15)ne	1 p. 198, 686
0.1 mf CP04A1KE104M (3 ea)	3.3 (10)	1.1 (15) ne	Capacitance (+17%) @ 1.11(15)ne, 1 opened	2 p. 297
0.1 mf CP25A1EF104K (3 ea)	2.6 (10)	1.1 (15) ne	Capacitance (-20.5%) @ 5.81 (14)ne	2 p. 303
0.5 mf CP53B1FF504K (3 ea)	4.6 (10)	6.9(15)ne	Capacitance, All failed < 3(15)ne	2 p. 321
0.5 mf CP53B1EF504K (3 ea)	2.9 (10)	2.4 (15) ne	Capacitance (-18%) @ 9.9(14)ne, 2 shorted	1 p. 215
0.5 mf CP53B2FF504K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-36.2%) @ 2.19(14)ne	1 p. 225, 687
1 mf CP63B1EF105K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-32.6%) @ 3.36(14)ne	1 p. 229, 687
10 mf CP70E1EF106K (3 ea)	2.7 (10)	1.3 (15) ne	Capacitance (-31.9%) @ 2.09(14)ne	1 p. 249, 687

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>Crocker, Burbank Paper, Inc.</u>				
0.5mf, 400 vdc Metal clad tubular, Impregnated with refined Sun-XX oil	1(10)		Capacitance decreased about 3% @ 25°c & 7% @ 125°c, D.F. more than doubled @ 25°c & increased 6 times @ 125°c, I.R.(-33%) @ 25°c & (-12.5%) @ 125°c. The paper was also weakened & shorted when voltage was applied.	70p 32
<u>Electron Products Division, Preco, Inc.</u>				
0.1 mf, 200 vdc (Metalized) MG2-104 (2 ea)	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-95.2%)	12p 191
" (2 ea)	3.9 (8)		Leakage R(-44%) @ 6.88(6) ergs/gm-(C)	12p 184
0.1 mf @ 200 vdc ± 10% (Metalized) encased in epoxy tube, ME2-104E (Epicon)	7.6(9)	3.7 (15) (E>1 Mev)	Leakage R(-83%) @ 2.79(15) nf	12p 202
0.1 mf ± 20%, DF<1% Metalized Paper Epoxy Impregnated M150 (1ea)	6.2 (10)	4.2 (16) (E> 1Mev)	Leakage R(-99.8%) @ 1.65(16)nf	12p 206
0.47 mf, 200 vdc Metalized Paper, Epoxy impregnated, wrap & end fill, M2-474	1.8 (10)	1.4 (15) (E>2.9Mev)	Leakage R(-94.7%)	12P 190
" (2 ea)	3.9 (8)		Leakage R(-44%) @ 6.88(6) ergs/gm-(C)	12p 184

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitor, Paper	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Micamold Radio Corp.				
0.1 mf CP04A1EE104 M (3ea)	3.3(10)	2.7 (15)ne	Capacitance (+18.5%) @ 2.6(15)ne	1p 180,686
" (3ea)	2.6(10)	1.1 (15)ne	Capacitance (+16.9%) @ 1.11(15)ne 1 shorted	2p 286
0.1 mf CP25A1KE104 M (3ea)	2.6(10)	1.1 (15)ne	Capacitance (+21.6%) @1.11(15)ne	2p 298
0.1 mf CP04A1KE104 M (3ea)	3.3(10)	2.7 (15)ne	Capacitance (+17.5%) @ 2.6(15)ne	1p 201,686
Sangamo Electric Co.				
0.1 mf CMP08	1(10)		Capacitance (-6%). Factor of 2 increase in dissipation factor, factor of 7 decrease in insulation R	70p 30
0.1 mf, Samica with C-oil solid impregnated	1(9)		30% of all capacitors tested failed under a voltage pulse of 2000v @ 135°C	70p 100
0.1 mf, Samica with mono-isopropyl-biphenyl dielectric fluid	1(10)		20% of all capacitors tested failed under a voltage pulse of 2000v @135°C	70p 100

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitor, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm^2		
Sprague Products Co.				
0.1 mf CP04A1EE104M (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(+24.1%) @ 6.8(14) ne 1 opened	2p 285,286
" (3 ea)	3.9(10)	2.7 (15)ne	capacitance (-17%) @ 3.6(14)ne	1p 188, 686
0.1 mf CP04A1EE104M (2 ea)	3.9(10)	2.7 (15)ne	capacitance (-18.5%)	1p 188, 686
" (3 ea)	2.6(10)	1.1 (15)ne	Capacitance (-21%) 1 shorted	2p 291
0.1 mf CP04A1KE104K (3ea)	2.6(10)	1.1 (15)ne	Capacitance (-26.2%) 1 shorted	2p 294
" (2ea)	3.9(10)	2.7 (15)ne	Capacitance (-19%)@ 3.95(14)ne	1p 204,687
0.1mf CP04A1KE104M (3 ea)	3.9(10)	2.7 (15)ne	Capacitance (-18.4%) @6.05(14)ne	1p 193,686
" (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(-28.5%) 1 shorted	2p 298
0.1 mf CP25A1EF104K (3 ea)	2.6(10)	1.1 (15)ne	Capacitance(-28.5%) 1 shorted	2p 311
0.1 mf, 200vdc 195P (Hyrel) (4 ea)	5.7(10)	2.4(17)nf	Capacitance(-12%) @ 1.1(17), all failed from outgassing	15p 17,20
0.47mf @600vdc Hi Density paper impregnated with standard amount of Vitamin Q (8ea)	1.9(10)		Paper deteriorates & capacitor burst due to outgassing of impregnant & paper, capacitance (-10%) at 4.38 (7)ergs/gm-(C)	55p 3, 11, 16
0.47mf @600 vdc Standard paper impregnated extra full with Vitamin Q (8 ea)	5.8(9)		Paper deteriorates & capacitor burst due to outgassing. capacitance (-8%) @ 4.38(7)ergs/gm-(C)	55p 3,11, 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES ergs / gm-(C)	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sprague Con't				
0.47mf @600vdc Hi density paper impregnated extra full with VitaminQ (8 ea)	1(10)		Paper deteriorated due to outgassing of impregnant & paper. capacitance (-1.8%) at 2.26(7)ergs/gm-(C)	55p 3, 11, 16
0.47mf @ 600vdc standard paper, standard impregnated with ether	1.9(10)		Paper gasses and becomes weak, brittle and flakey. Dissipation factor increases several orders of magnitude. Capacitance (-13%)	55p 3,11,17
0.47 mf @600vdc standard paper and impregnated with standard ether (extra full)	1.9(10)		Paper gasses and becomes weak, brittle and flakey. Capacitor ruptures due to out-gassing of paper and ether. Capacitance (-13%)	55p 3, 11, 17
0.47mf @600vdc Hi density paper and impregnated extra full with ether	1.9(10)		Paper gases and deteriorates. Capacitor ruptures due to outgassing of paper and ether. Capacitance (5.8%) @ 2.26(7)ergs/gm-(C)	55p 17
0.47mf @600vdc Hi density paper and impregnated with a standard load of ether	1.9(10)		Paper gases and deteriorates. Capacitor ruptures due to outgassing of paper and ether. Capacitance(-13.3%) @2.26(7)ergs/gm-(C)	55p 17
0.5 mf CP53B2FF504K (3 ea)	2.8(10)	1.4(15)ne	Capacitance (-19.5%) @ 2.25 (14)ne	1p 225

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Paper	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Sprague Con't				
0.5mf CP53B1EF504K (3 ea)	2.9(10)	2.4(15)ne	Capacitance (-17.3%) @ 3.97 (14)ne	1p 217,687
1 mf CP63B1EF105K (3 ea)	2.7(10)	1.4(15)ne	Capacitance (-30.2%)	1p 229,687
10mf CP70E1EF106K (3 ea)	2.7(10)	1.3(15)ne	Capacitance (-35.7%) @ 6.8(14)ne	1p 240,687

2.2 CAPACITORS

2.2.8 PLASTIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Plastic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm²		
Bendix Corp., Cincinnati Div.				
3000pf±10%, 600vdc Experimental, Modified Poylstyrene Dielectric (6 ea)	2.2(9)	5.6(14) (E>0.5Mev)	Capacitance(-2%)	35p 10.26-33
Plastic Capacitors Corp.				
0.01mf±10% Cellulose Acetate Dielectric, OG6-103 (6 ea)	2.4(10)	1.3(15)ne	Capacitance(-8%) 6 Failed - Shorted	2p 327
0.02mf, Teflon Dielectric, TG75-202 (6 ea)	3.1(10)	9.6(14)ne	Capacitance(+14%)	2p 332
1mf, OC6-105 (6 ea)	9.1(10)	2.4(15)ne	Capacitance(+11%) 5 failed	5p 71
Hopkins Engineering Co.				
0.1 mf @ 100 vdc± 1% Polystyrene dielectric P11PF	1.9(10)	1.5(15) (E>2.9Mev)	Leakage R (-96.9%) @ 5.2(8)ergs/gm-(C)	12 p 192
"	7.6(9)	3.8(15) (E>1 Mev)	Leakage R (-87.5%) @ 1.1(7)ergs/gm-(C)	12 p 198

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Plastics	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sprague Products Co.				
0.3mf, 1000vdc Polyester dielectric in dry metal can Type 65213 (4 ea)		1.1(17) (E>0.5Mev)	Capacitance(-10%) 1 failed	35p 10.39-43
0.3mf, 1000vdc Polyester dielectric with oil-filled can Type 65214 (5 ea)		1.1(17) (E>0.5Mev)	Capacitance(-10%) 3 failed	35p 10.39-43
Western Electric Co.				
0.04mf Polystyrene dielectric (4 ea)	5.7(10)	2.4(17)nf	Capacitance(+8%) @ 6(16)nf, 1 failure	15p 17,18

2.3 **COAXIAL CABLES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Coaxial Cables	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Amphenol-Borg Electronics Corp.				
RG-29/U Polyethylene (Amphenol #21-018) Z = 53.5 ohms	1.3(9)	2.2(14) (E>0.5Mev	Z (± 9.7%) Leakage R increased by factor 100	35 p 10.90
RG 59/U Polyfoam Equivalent (Amphenol #621-715) Z 73 ohms	1.3(9)	2.4(14) (E>0.5Mev)	Z (± 31%) Leakage R fairly constant	35 p. 10.90
Andrews Corp.				
Air Dielectric Type with "Refrasl" insulator, 43 ohms 3/8" diameter (50ft)	~1(11)		Insulation R decrease factor~100 VSWR 1.15: 1.26 unable to maintain air pressure in cable due to silicone grease leak	4 p 8-15
Prodelin, Inc.				
RG-260/U 50 ohm "Spir-O-Line" (3ea)	7 (10)	6.1(16) (E>0.3Mev)	Attenuation(±13%) at 4.1(16)nf, Z ± 2 ohms	31 p 173-189
Raychem Corp.				
RG-8/U Equivalent Polyolefin (09-008R)	2.5(11)	1.9(17) (E>1 Mev)	Z(±7%) at 2(10)e/g-c Attenuation(±8.3%)at 2.5(10) e/g-c	30 p. 111-122
RG-9/U Equivalent 50 ohms, Raylin R(3ea)	7(10)	6.1(16) (E>0.3Mev)	Attenuation(±11%) at 4.8(16)nf Z ±- 2 ohms	31 p. 173-189

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Coaxial Cables	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Rockbestos Products				
Aircraft Cable, Hi-Temp, Fire Resistant, Ni Clad Cu Wire, Inorganic Barrier, Impregnated Teflon Jacket & Glass Braid	3.7(10)	1.9(15) ne	Insulation R decreased by order ~100	60 p42, 36, 46, 61
Thomas A. Edison Industries				
Solid Dielectric Type Silica Dielectric, 50 ohms, 0.170" diameter (48 ft)	~1(11)		Insulation R decreased by order ~100 VSWR 1.05:1.11	4 p8-15
Times Wire and Cable				
RG-8A/u Standard Mil-C-17 (3 ea)	2.7(11)	1.9(17) (E > 1 Mev)	Z (+10%) @ 5(8)ergs/g-(C), attenuation (± 4.76%)	30 p111-122
Miscellaneous				
RG-225/u Teflon (60 ft.)	2(9)	1(16) (E>0.1 Mev)	VSWR 1.09:1 Teflon cracked & soft	10 p24

2.4 CONNECTORS, ELECTRICAL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Amphenol-Borg Electronics Corp.				
AN-3102A-12S-3P & S (1ea)	2.4(8)		Leakage I increased by factor $\sim 10^4$	14 p 11
26-4100-32P 32 contacts (1ea)	2.2(10)	1.6(14)ne	R between pins increased by factor $\sim 10^5$	5 p 129
Bendix Corp.				
AN Hi-Temp Type (Scintilla Div) Mil-C-5015-C, Series K, 20 Amp, 700vdc or 500vac, Glass-Bonded Mica and Silicone Rubber (6ea)	1.4(9)	2.5(14) (E>0.5Mev)	Leakage R decreased by factor >10, not rec. for nuc. environments	35 p 10.100
PT06CE-8-4S (Bendix Special Blend rubber insert) (1 ea)	1.3(9)	8.7(11)nf 1(12)nt	Insert swelled and Turned gray. Good condition.	8 p 113-120
PT00SE-12-10P and PT06SE-12-10S (Neoprene Inserts) (3ea)	1(9)	5.1(15) (E>0.1Mev)	Pin/Pin R decreased by order $\sim 10^3$	10 p 141
PT 1H-1210P (hermetic Seal)(2ea)	1(9)	5.1(15) (E>0.1Mev)	Pin/Pin R decreased by order $\sim 10^4$	10 p 141

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>Cannon Electric Co.</u>				
CAOZHR-14S-55 & 5P (1 ea)	2.4(8)		Leakage I increased factor ~10^4	14 p 11
CA02HR-20(2006-44)P 14 pins, ceramic inserts	1.2(9)	1.8(15) (E>0.5Mev)	Insulation R decreased factor ~100, No other damage	35 p 10.105
CA06HR-20(2006-44)S 14 pins, ceramic inserts	1.2(9)	1.8(15) (E>0.5Mev)	Insulation R decreased factor ~100, no other failure	35 p 10.105
DA-15S & 15P-(C-7) (1 ea)	2.4(8)		Leakage I increased by factor ~10^4	14 p 11
HR Type (4ea)	6.2(9)	2.2(16)nf (E>0.5Mev)	Contact R increased factor ~10 All Survived	4 p 54
"	4.4(9)	2.2(14)nf	Contact R Changes from 7.8(-4) → 63(-4), No change in insulation R	72 p 78
"	3.8(10)	1.03(16)nf	Contact R Changes from 6.3(-4) → 1000(-4), No change in insulation R	72 p 78

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Deutsch Co.				
262DTK00-12-10P and 262DTK06-12-10S (Silicone Rubber and diallyl phthalate Inserts) (1ea)	1(9)	5.1(15) (E>0.1Mev)	Pin/Pin R decreased factor ~100	10 p 140
Deutsch with silicone rubber inserts	7.2(10)	4.8(16) (E > 1Mev)	Leakage R (-91.6%) at 1.45(16)nf	12 p 229
Seal Corp.				
Hermetic glass type	7.5(10)	4.8(16) (E > 1Mev)	Leakage R(-92.7%) at 1.8(16)nf	12 p 231
Titeflex, Inc.				
H06-7-50S-9 Type	1.3(9)	8.7(11)nf 1(12)nt		8 p 117
with: RTV-90potting			Good condition	
with: PR1201-Q "			" "	
with: Teflon (TFE)"			Soft but o.k. (Not Rec. for use in Nuc. Environment)	

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Connectors, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Winchester Electronic Inc.				
Winchester connectors with the following inserts: Diallyl phthalate	7.5(10)	4.8(16) (E>1Mev)	Leakage R(-90.9%) at 2.7(16)nf	12 p 233
: Melamine Formaldehyde	"	"	Leakage R (-92.5%) at 1.8(16)nf	12 p 232
: Phenolic Formaldhyde	"	"	Leakage R(-99.2%) at 1.5(16)nf	12 p 229

2.5 CORES, COMPUTER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Cores, Computer	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Engineered Magnetics Corp.				
EM # W30-2-1207 Mag. Metals 2A-8602 Wire: 40 HF Potting: Hysol 6620 Cup: 22042-1A (2 ea)	6.7(8)	4.8(15) (E > 0.1MEV)	V_s(+7.8%) at 1.4(14) nf, I_s (+48%) at 3.3(13)nf	10 p. 23, 163
EM #W29-2-1207 Arnold Eng.6T534052 Wire: 40 HF Potting: Hysol 6620 Cup: 22042-1A (2 ea)	6.7(8)	4.8(15) (E > 0.1MEV)	V_s (+ 7.5%) and I_s (+ 55.5 %) at 3.3 (13) nf	10 p. 23, 163
EM #W 32-2-1207 Mag. Metals 75A-4602 Wire: 27HF Insul: HL 1/2 Mil Mylar (2 ea)	6.7 (8)	4.8 (15) (E > 0.1MEV)	V_s(+ 5%) at 1.4(14), I_s(-52.3%) at 2.8 (12) nf	10 p. 23, 163
EM #W31-2-1207 Arnold Eng.2T5772R4 Wire: 25 HF Insul: HL 1/2 MIL Mylar (2 ea)	6.7(8)	4.8 (15) (E > 0.1MEV)	V_s (-3.15% and I_s (+ 104%) at 4 (12)nf	10 p. 23, 163

2.6 **CRYSTALS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
CR-16/U				
120Kc "DT" Cut Quartz in HC-5/U Holder	3.6(10)	5.7(13)nf		2 p769, 660
James Knights Co. (2 ea)			Parallel Resonant Freq. (-94.1 ppm)@2.5(13)nf Ser. Resonant Freq. (-128.3ppm)@1.2(12)nf	
Midland Manufacturing Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. (+140ppm)@4.9(13)nf Series Resonant Freq. (failed)	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) Series Resonant Freq.(-538.3ppm) @ 1.2(12)nf	"
CR-(XM-17)/U				
17Mc Gold Plated Glass Holder (5 ea)	8.8(9)		Freq.(- 0.880Kc)	27 p4-15, A-8
" (5 ea)		3.6(12) p/cm^2	Freq.(- 0.087Kc)	27 pA-10

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-18/U				
5275Kc ±0.0005%, (12 ea)	2.7(9)	7.4(13) (E>2.9Mev)		22 p3,59
Scientific Radio Products, Inc.			Resonance Frequency (50 ppm)	
4Mc Anti-resonant Alum. plated, metal holder Y-Bar synthetic quartz (5 ea)		3.6(12) p/cm²	Freq. (- 0.042Kc)	27 p15,A-2
13.025Mc, Unpolished Finish, Compression Base	3.8(10)	2.9(14)nf		35 pA-73-77
Scientific Radio Products Inc. (3 ea)			Frequency (-1355ppm)	
17Mc Alum. Plated Anti-resonant, Metal Holder (5 ea)	8.8(9)		Freq. (- 0.875Kc) @ 6.5(7)ergs/gm-(C)	27 p4-15, A-5
" (5 ea)		3.6(12) p/cm²	Freq. (- 0.080Kc)	27 pA-6
CR-19/U				
1Mc "AT" Cut HC-6/U Holder	1.7(10)	2.1(13)nf		2 p666, 769
James Knights Co. (3 ea)			Parallel Resonant Freq. (+46.5ppm) @ 2.3(12)nf, Series Resonant Freq. failed @ 1(13)nf	

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-19/U (Cont.)				
Midland Mfg. Co., Inc. (2 ea)	1.7(10)	2.1(13)nf	Parallel Resonant Freq. (-343.2ppm), Series Resonant Freq.(failed) @ 1(13)nf	2 p666, 769
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 9.4(12)nf Series Resonant Freq. (-1134.4ppm)	
Wright Electronics, Inc., (2 ea)	"	"	Parallel Resonant Freq. (+19.5ppm) @ 5.2(12)nf Series Resonant Freq. (-2217 ppm)	
12Mc "AT" Cut Quartz HC-6/U Holder	3.5(10)	2.1(15)ne		2 p672, 769
Midland Manufacturing Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. - failed @ 2.3(14)nf Series Resonant Freq. - failed @ 2.3(14)nf	
Scientific Radio Products Inc.(2 ea)	"	"	Parallel Resonant Freq. (-4925ppm), Series Resonant Freq.(-3971ppm)	
Sherold Crystals, Inc. (2 ea)	"	"	Parallel & Series Resonant Freq. - failed @ 3.3(14)nf	
Wright Electronics (2 ea)	"	"	Failed @ 3.5(14)nf	
20Mc "AT" Cut Quartz HC-6/U Holder	1.8(10)	1(15)ne		2 p769, 680-689
Wright Electronics (2 ea)	"	"	Parallel Resonant Freq. (failed @ 7.9(14)ne) Series Resonant Freq. (failed @ 7.5(14)ne)	

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
CR-23/U				
29.3 Mc, "AT" Cut Quartz				
Midland Mfg. Co. Inc. (3 ea)	2.3(10)	1.8(16) (E>0.3Mev)	Freq. (+60ppm)	31 p14-48
40Mc, AL. plated Crystals				
Midland Mfg. Co. Inc. (2 ea)	3.2(10)	1.4(15)ne	Freq. (-44.4ppm)	35 pA-94
Scientific Radio Products. Inc. with following:				
(1) Au Electrodes, polished Quartz, metal holder with compression base (2 ea)	3.1(10)	2(15)ne	Freq. (-1120 cps) @ 1.6(18) ergs/gm-(C)	35 pA-19-24
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (+2863 cps)	"
(2) Same as (1) except standard base (2 ea)	"	"	Freq. (-2743 cps) @ 6.7(14)ne	35 pA-25-30
" (2 ea)	3.1(10)	2(15)ne	Freq. (+2216 cps) @ 5.7(9) ergs/gm-(C)	"
(3) Same as (1) except unpolished (2 ea)	"	"	Freq. (-2861 cps)@ 4.8(18) ergs/gm-(C)	35 pA-31-35
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (+5773 cps) @ 2.1(16)ne	"
(4) Same as (3) except standard base (2 ea)	"	"	Freq. (-625 cps) @ 9.4(14)ne	35 pA-36-40
" (2 ea)	3.1(10)	2(15)ne	Freq. (+1579 cps) @ 6(9) ergs/gm-(C)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-23/U 40Mc (Cont.)				
Scientific Radio Products, Inc. (Cont.)				
(5) Au Electrodes, unpolished quartz plate, all-glass holder, T6½ (2 ea)	3.1(10)	2(15)ne	Freq. (-1799 cps) @ 1.6(8) ergs/gm-(C)	35 pA-41-45
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-674 cps) @ 1.4(15)ne	"
(6) Al Electrodes, polished quartz plate, metal holder with compression base (2 ea)	1.9(10)	2.4(16)ne	Freq. (-971 cps) @ 9.4(14)ne	35 pA-46-50
" (2 ea)	3.1(10)	2(15)ne	Freq. (-1268 cps) @ 1.8(8) ergs/gm-(C)	"
(7) Same as (6) except standard base (2 ea)	"	"	Freq. (-614 cps) @ 1.8(18) ergs/gm-(C)	35 pA-51-55
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-934 cps) @ 1.1(16)ne	"
(8) Same as (6) except unpolished plate (2 ea)	"	"	Freq. (+1259 cps) @ 2.1(16)ne	35 pA-56-60
" (2 ea)	3.1(10)	2(15)ne	Freq. (-1670 cps) @ 1.8(8) ergs/gm-(C)	"
(9) AL Electrodes, unpolished plate, metal holder with standard base (HC-6/U) (2 ea)	"	"	Freq. (+1137 cps) @ 6.4(9) ergs/gm-(C)	35 pA-61-65
" (2 ea)	1.9(10)	2.4(16)ne	Freq. (-1228 cps) @ 1.1(15)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-23/U 40Mc (Cont.)				
Scientific Radio Products, Inc. (Cont.)				
(10) Same as (9) except all-glass holder T6½ (2 ea)	"	"	Freq. (+1215 cps)	35 pA-66-70
" (2 ea)	3.1(10)	2(15)ne	Freq. (-814 cps) @ 1.8(8) ergs/gm-(C)	"
45Mc, Al plated Crystals				
Midland Mfg. Co. Inc. (2 ea)	3.2(10)	1.4(15)ne	Freq. (-25.2ppm)	35 pA-94
M-23				
14.27 Mc, Ag plated Crystal, metal holder				
McCoy Electronics Co. (2 ea)	3.2(10)	1.4(15)ne	Failed to oscillate, One open - circuited	35 pA-91

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-24/U 25 Mc ±50 ppm, "AT" Cut Quartz in HC-10/U Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.4(10)	2.1(15)ne 5.4(13)nf	Parallel Resonant Freq. (failed) @ 1.2(15)ne, Series Resonant Freq. (-21.4 ppm) @ 1.9(13)ne	2 p769, 690-697
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (+35.4 ppm), Series Resonant Freq. (-42.8 ppm) @ 1.9(13)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Series and Parallel Freq.'s (failed) @ 1.2(15)ne	"
CR-25/U 300Kc ±100 ppm, Metal plated, "DT" Cut Quartz in HC-6/U metal holder				
Midland Mfg. Co., Inc., (2 ea)	1.7(10)	6.1(14)ne 2.1(13)nf	Parallel Resonant Freq. (+688.3 ppm), Series Resonant Freq. (+388.3 ppm)	2 p769, 698-707
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (+117.3 ppm), Series Resonant Freq. (+122 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-25/U (Cont.) 300Kc(Cont.)				
Wright Electronics, Inc. (2 ea)	1.7(10)	6.1(14)ne 2.1(13)nf	Parallel Resonant Freq. failed @ 1.3 (14)ne, Series failed on insertion	2 p769, 698-707
CR-27/U				
833.33 Kc ±30 ppm				
Scientific Radio Products, Inc. (12 ea)	2.7(9)	7.4(13) (E>2.9Mev)	Frequency (18 ppm)	22 p3, 59
3400 Kc ±30 ppm				
Scientific Radio Products, Inc. (12 ea)	"	"	Frequency (21 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-32/U				
56.99Mc ±34 ppm				
Scientific Radio Products, Inc. (12 ea)	2.7(9)	7.4(13) (E>2.9Mev)	Frequency (33 ppm)	22 p3, 59
CR-38/U				
60Kc ±120 ppm, Metal plated, "NT" Cut Quartz, HC-13/U Metal holder				
James Knights Co. (2 ea)	3.4(10)	2.1(15)ne 5.4(13)nf	Parallel Resonant Freq. (-83.3 ppm) @ 3.5(14)ne, Series Resonant Freq. (-121.6 ppm)	2 p769, 703-707
Midland Mfg. Co., Inc., (2 ea)	"	"	Parallel Resonant Freq. (Failed) @ 1.5(15)ne, Series Resonant Freq. (-341.6 ppm)	"
Wright Electronics, Inc. , (2 ea)	"	"	Parallel Resonant Freq. (Failed) @ 1.5(15)ne, Series Resonant Frequency (Failed) @ 3.9(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-39/U				
200 Kc, "GT" Cut Quartz (unpolished), Vacuum Tube Type Holder				
Bliley Electric Co. (3 ea)	2(10)	1.5(16) (E>0.3Mev)	Frequency (-115ppm)	31 p14-48
250Kc ±30 ppm @ 25°C Metal plated "GT" Cut Quartz, Vacuum Tube Type Holder				
James Knights Co. (4 ea)	2.7(10)	9.5(14)ne 3.3(13)nf	Parallel Resonant Freq. (-68 ppm) @ 1.4(14)ne, Series Resonant Freq. (-103.6 ppm) @ 1.8(14)ne	2 p769, 708-714
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-168.4 ppm) @ 1.8(14)ne, Series Resonant Freq. (-126.8 ppm)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-47/U 300 Kc, Fund. Freq. Gold Plating, Metal Holder Antiresonant (4 ea)	8.8(9)		Frequency (-29 cps)	27 p4-15,A-24
" (5 ea)		3.6(12) p/cm2	Frequency (+3 cps)	27 p4-15, A-26
CR-51/U 13.025, Al Electrodes, Standard HC-6/U, glass base, unpolished Scientific Radio Products, Inc. (3 ea)	3.5(10)	2.2(15)ne	Frequency (-456ppm) @ 1.3(13)ne	35 pA-78-84
CR-52/U 15 Mc ±50 ppm, Metal plated "AT" Quartz, HC-6/U, Metal Holder Midland Mfg. Co., Inc. (2 ea)	3.9(10)	2.4(15)ne	Parallel Resonant Freq. (failed) @ 3.1(14)ne	2 p770, 715-723

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
CR-52/U (Cont.)				
15Mc (Cont.)				
Scientific Radio Products, Inc.	3.9(10)	2.4(15)ne	Parallel Resonant Freq. (-1664 ppm), Series Resonant Freq. (-262 ppm) @ 1.1(15)ne	2 p770,715-723
Sherold Crystals, Inc. (2 ea)	"	"	Series & Parallel Freq. (failed) @ 2.1(14)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2042 ppm), Series Resonant (Circuit Malfunctioned)	"
18Mc, Au plated, Series Resonant, Metal Holder (5 ea)	8.8(9)		Frequency (-1006cps)	27 p4-15, A-17
" (5 ea)		3.6(12) p/cm^2	Frequency (-114 cps)	27 p4-15, A-19
19.5Mc, Al Electrodes, Unpolished, Compression bases				
Scientific Radio Products, Inc. (3 ea)	3.8(10)	2.4(15)ne	Freq. (-418 cps) @ 2.7(14)ne	35 pA-85-89

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-52/U (Cont.)				
50Mc ±50 ppm, Metal plated "AT" Cut Quartz in HC-6/U Metal Holder				
Midland Mfg. Co. Inc. (2 ea)	1.8(10)	1(15)ne	Series & Parallel Resonant Freq.(failed) @ 6.7(14)ne	2 p770, 724-734
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-1392ppm), Series Resonant Freq. (-1988ppm)	"
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 9.8(14)ne, Series Resonant Freq. (-2173ppm)	"
Wright Electronics Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2580ppm), Series Resonant Freq. (-1669ppm)	"
CR-53/U				
70Mc, "AT" Cut Quartz Au plated, polished with Metal Compression Base				
Midland Mfg. Co. Inc. (3 ea)	2.1(10)	1.8(16) (E>0.3Mev)	Frequency (+76ppm) One failed @ 1.2(16)nf	31 p14-48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs / gm-(C)	n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-54/U				
60 Mc ±50ppm, Metal Plated "AT" Cut Quartz HC-6/U Metal Holder				
James Knights Co. (2ea)	3.5(10)	2.1(15)ne	Parallel Resonant Freq. (-26ppm) @ 2.7(13)ne, Series Resonant Freq. (-29ppm)@1.5(15)ne	2 p770,735-745
Midland Mfg. Co., Inc. (2 ea)	"	"	Parallel Resonant Freq. (-26ppm) @ 4.7(12)ne, Series Resonant Freq. (-50ppm) @ 1.5(15)ne	"
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 1.5(15)ne, Series Resonant Freq. (-442ppm) @ 1.2(15)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-4362ppm), Series Resonant Freq. (failed) @ 1.3(15)ne	"
75Mc ±50ppm, Metal Plated, "AT" Cut Quartz, HC-6/U Metal Holder				
Midland Mfg. Co. Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-110.5ppm), Series Resonant Freq. (+46.1ppm) @ 3.7(13)ne	2 p770,746-752

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR-54U (Cont.)				
75Mc (Cont.)				
Scientific Radio Products, Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-1141.3ppm) @ 1(15)ne, Series Res. Freq. (-930.3ppm) @ 8.5(14)ne	2 p770,746-752
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-2750.6ppm), Series Resonant Freq. (-2362.7ppm)	"
Wright Electronics, Inc.	"	"	Parallel Resonant Freq. (-2605.6ppm), Series Resonant Freq. (-3533.3ppm)	"
85Mc, Al Plating, Series Resonant, Metal Holder (5 ea)	8.8(9)		Frequency (+8768cps)	27 p4-15, A-20
" (5 ea)		3.6(12) p/cm²	Frequency (-466cps)	27 p4-15, A-23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
CR-55/U 40Mc ±50ppm, Metal Plated, "AT" Cut Quartz HC-18/U Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.1(10)	1.1(15)ne 3.6(13)nf	Series & Parallel Freq. (failed) @ 5.6(14)ne	2 p770, 753-758
Scientific Radio Products, Inc. (2 ea)	"	"	Parallel & Series Resonant Freq. (failed) @ 5.6(14)ne	"
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (-641.8ppm), Series Resonant Freq. (failed)	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 5.6(14)ne, Series Resonant Freq. (failed) @ 8.2(14)ne	"
CR-56U 70Mc ±50ppm, Metal Plated, "AT" Cut Quartz HC-18/U Subminiature Metal Holder				
Midland Mfg. Co., Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-27.9ppm) @ 2(12)ne Series Resonant Freq. (-10.5ppm) @ 2(12)ne	2 p760-770

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CR56/U (Cont.)				
70 Mc (Continued)				
Scientific Radio Products. Inc. (2 ea)	3.7(10)	1.8(15)ne 5.1(13)nf	Parallel Resonant Freq. (-2481ppm), Series Resonant Freq. (failed) @ 1(15)ne	2 p760-770
Sherold Crystals, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 4.2(14)ne, Series Resonant Freq.(failed) @ 5.8(14)ne	"
Wright Electronics, Inc. (2 ea)	"	"	Parallel Resonant Freq. (failed) @ 8.7(14)ne, Series Resonant Freq.(failed) @ 1.8(15)ne	"
CR-74/U				
47.5Mc, Ag Plated, Glass Holder				
McCoy Electronics Co. (2 ea)	3.2(10)	1.4(15)ne	Frequency (-29.8ppm)	35 pA-91
62.5Mc, Ag Plated, Glass Holder				
McCoy Electronics Co. (2 ea)	"	"	Frequency (-30.4ppm)	"

2.7 DELAY LINES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Delay Lines	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Corning Glass Works				
100 µ sec Pb-Potash Glass Delay Piezoelectric Ceramic Transducers, Type 852798 S/N 32001 Corning Series C-Z (1 each)	7.6(10)	5.7(16) (E>.3 Mev)	No effect from radiation observed at the time of instrumentation failure @ 1.5(16) nf and 2(10)ergs/gm-(C)	31 p 239-263
General Electric Co.				
2 µ sec Transmission Media is Ni Span C, magneto-strictive Type - Alnico V & Ni Alloy Experimental (1 each)	2.1(11)	6.8(16) (E>1 Mev)	Output - 95% @ 3.16(16) nf (failed)	30 p 157-162
170 µ sec Same composition as 2 u sec delay Line Experimental (1 each)	5.8(10)	5(16) (E>.3 Mev)	No change in delay time. Output signal begins to degrade @ 5.3(15) nf & 6(8) ergs/gm-(C)	31 p 239-263
298 µ Sec Transmission wire is Ni Span C, Ceramic Transducer is PZT Type, Experimental (1 each)	5.8(10)	5(16) (E>.3 Mev)	No change in delay time. Output (-50%) @ 2.5(15) nf & 3.3(9) ergs/gm-(C)	31 p 239-263

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Delay Lines	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	LASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
NYT Electronics, Inc. 1.0 ±5% μ sec Z = 1K ±10%, 500 vdc Attenuation (25% Max) Rise Time = 0.15 μsec Max., Mil-C-15305A, Grade 1, Class B (6 each)		5.3(16) (E>.5 Mev)	Delay time average (-2.3 %). Rec. for use in Nuclear Environment	35 p 10.137

2.8 DIELECTRIC MATERIALS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Dielectric Materials	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
EI Dupont De Nemours & Co.				
Mylar Sheet, Type "C" Polyester	1(10)		No effect noted	70 p30
Orlon	1(10)		Thickness (+140%), Tensile Strength (-60%), Tonque Tear (-91.5%)	70 p35
Electrical Industries, Inc.				
Compression glass end seals	1(10)		No effects noted	70 p29-30
Hooker Chemical Corp				
FS-5 (Trifluorovinyl chloride polymer)	1(10)		0.235 cc gas formed per cc of material	70 p 23, 28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Dielectric Materials	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Minnesota Mining & Mfg Co.				
FC-43 (Perfluoro-Tri-butyl-amine)	1(10)		0.18 cc gas formed per cc of material	70 p23,28
Niemand Industries				
Kraft Paper Insulators	1(10)		Paper becomes brittle and cracks on handling	70 p30
Republic Foil Co.				
Aluminum Foil	1(10)		No effects noted	70 p30
Stevens Paper Mill				
Kraft Dielectric Tissue	1(10)		Tissue becomes brittle and cracked	70 p30

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Dielectric Materials	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Miscellaneous				
Bis (Phenoxyphenyl) Ether	1(10)		0.003 cc gas formed per cc of material	70 p28
Chlorinated Biphenyl (Aroclor 1254 with added stablizer of the quinone type)	1(10)		0.0246 cc gas formed per cc of material	70 p28
Etherm "A" (Mineral oil, Sun XX with added stablizer of the quinone type)	1(10)		1.97 cc gas formed per cc of material	70 p28
Etherm "B" (Mixture of Polybutene (Ornite 32-X) and water-white mineral oil, stablizer of the quinone type)	1(10)		1.79 cc gas formed per cc of material	70 p28
Monoisopropylbiphenyl	1(10)		0.0917 cc gas formed per cc of material	70 p28

2.9 GLASS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Corning Glass Works				
Type 1723 Alumino Silicate(5ea)		5.8(18)nt	All enclosures o.k. but Gassy	49 p.8, 11
" (5 ea)		9.2(16)nt	Badly discolored Questionable Reduction in stress	49 p.8, 12
Type 7052 No leads (5 ea)		3.6(18)nt	Some enclosures leaky, all gassy	49 p.6, 11
Types 7056 Enclosure with kovar leads (5 ea)		7.5(17)nt	All enclosures o.k. but gassy	49 p.11
Type 7720 Nonex under vacuum (2ea)		2.1(17)nt	Both cracked	49 p.11
" in air (2ea)		7.5(17)nt	1 cracked	49 p.11
" with Ni-W-Ni leads (5 ea)		5.8(18)nt	Some leakers all gassy	49 p.11

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Glass	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Kimble Glass Co., Sub. Owens-Illinois Glass Co.				
Type 51-26 Boron-Free (5ea)		9.2(16)nt	Slight discoloration, Questionable Reduction in stress	49 p.11
" Enclosures with Moly leads (5ea)		5.8(18)nt	All enclosures o.k., no trace of gas	49 p.8, 11
Type 57-529 5% B_2O_3 (5 ea)		9.2(16)nt	Some discoloration, Questionable reduction in stress	49 p.8, 12
Type 58-20 3% B_2O_3 (5ea)		9.2(16)nt	Some discoloration, Questionable reduction in stress	49 p.8, 12

2.10 INDUCTORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Inductors	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Arnold Magnetics Corp.				
Type 384-3000 3 hy, Toroidal (12ea)		4.3(16) (E>0.5Mev)	Induction (5%) DC Resistance (10%) No damage	35 p 10.139-141
Engineered Magnetics Corp.				
Type G 357 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(-8.1%)	10 p 23, 162

2.11 INSULATION, ELECTRICAL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Dow Corning Corp.				
DC-675 (Methyl Phenyl Polysiloxane Silicone Elastomer)	1.3(10)		Shore A Durometer Hardness(+54%) compression set (+90%)	69 p23,31
Silastic 80 (3 ea) Wire Insulation		4.1(16) (E>0.5Mev)	Insulation R (failed) Cracked and brittle	35 p10.96-100
General Aniline & Film Co.				
Gafite (Methyl Alpha-Chloroacrylate)	3.2(8)		Luminous Transmittance (-66%)	57 p10
"	1(9)		Tensile Strength = 20% of original	57 p12
"	3(9)		Flexural Strength = 10% of original	57 p13
"	1(10)		Heat Distortion Temperature (-15%)	57 p14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Insulation, Electrical	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
General Electric Co.				
SE-361 (Methylvinyl Polysiloxane) Silicone Elastomer	1.3(10)		Shore A Durometer Hardness (+75%) Compression Set - (+334%)	69 p23, 31
SE-551 (Methylphenyl Polysiloxane) Silicone Elastomer	1.3(10)		Shore A Durometer Hardness (+100%) Compression Set - (+2400%)	69 p23, 31
SE-975 (Wire Insulation)		4.1(16) (E>0.5Mev)	Insulation Resistance (failed) cracked and brittle	35 p10.96-100
XE-9003A (Wire Insulation)		4.1(16) (E>0.5Mev)	Insulation Resistance (failed) cracked and brittle	35 p10.96-100
Kish Industries, Inc.				
358G (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	Large variation in volume resistivity	35 p10.85-88
412M (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 p10.85-88
420A (Also for potting)	1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 p10.85-88

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Marblette Corp.				
Maraset 622-E (Also used for potting)	1(11)	1.1(16) (E>0.5Mev)	Volume resistivity (+1900%), Dissipation factor (+1570%) Dielectric Constant (No change)	35 p10.85-86
Marblette 3056 with Boron (Primarily used for neutron shielding)	1(11)	1.1(16) (E>0.5Mev)	Electrical characteristics failed @ 1.5(15)nf	35 p10.85-86
McDanel Refractory Porcelain Corp.				
AP 35 (Ceramic Alumina) in a boiling dissolver solution of 1M Nitric Acid with 75 g/l Stainless steel metal components. Material unaffected in this solution with no weight loss.	1(11)		Impact strength - (+39%), Compressive strength (+26%), Volume resistivity decreases by factor ~100	64 p15
	1(12)		Impact strength - (+18.5%), Compressive strength (<1%)	64 p15

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Insulation, Electrical	ergs / gm-(C)	n / cm^2		
Minnesota Mining & Mfg. Co.				
Scotchcast 5 (also used for potting)	~1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 p10.85-88
Scotchcast 212 (also used for potting)	~1(11)	1.1(16) (E>0.5Mev)	No damage, good up to 1.1(16)nf	35 p10.85-88
Mycalex				
Supramica 555	1.2(10)		Material becomes brittle	33 p2,8
Mycalex Bobbin		2.2(14) (E>0.5Mev)	Warped	35 p10.123
Pennsalt Chemical Corp.				
KYNAR (Polyvinylidene Fluoride Resin) in boiling dissolver solution of 1M nitric acid with 75 g/l stainless steel metal components. Resistant to this solution but undergoes slight weight gain	1(10)		Impact strength - (41.4%), Compressive strength - (+4.2%)	64 p15
	1(11)		Impact strength (-27%) Compressive strength (-37%), Volume Resistivity decreases by factor ~ 10^3	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Phillips Petroleum Co.				
MARLEX (Hi-density Polyethylene of Polyolefin Resin family) In boiling dissolver solution of 1M Nitric Acid with 75 g/l stainless steel metal components. Resistant to solution with no weight loss.	1(10)		Impact strength (-4.3%), Compressive strength (<<1%)	64 p15
	1(11)		Impact strength(-85%) Compressive strength (0.0%), Volume resistivity decreases by factor $\sim 10^5$	"
Raychem Corp.				
Modified Polyolefin	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition	8 p118
Rayclad Tubes, Inc.				
Thermofit Tubing (Modified Polyolefin)	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition	8 p118

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Rohm & Haas Co.				
Plexiglas 55 (methyl Methacrylate)	5(8)		Luminous Transmittance (-33%)	57 p10
	1(9)		Tensile strength(-10%)	"
	1(10)		Flexural strength = 10% of original, Heat distortion temperature (-20%)	"
Sierracin Corp.				
Sierracin 611 Polyester	1(10)		Luminous transmittance (-52%), Tensile strength (+20%), Flexural strength (+5%), Heat distortion temp. (-20%)	57 p10
Miscellaneous				
Diallyl Phthetate (in Winchester Plug)	7.5(10)	4.8(16) (E>1Mev)	Leak R (-91%) @ 2.7(16) nf	12 p233
Fiberglass Impregnated with Teflon	1.3(9)	8.7(11)nf 1(12)nt	Survived in good condition but has temperature limited use.	8 p118

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>Miscellaneous (Cont.)</u>				
Fiberglass (Epoxy coated) Insulating Sheet	3.3(9)	8(15)ne	Tensile strength (-60%), Ultimate Elongation (-55%)	65 p10 Table IV
"	3.1(11)	9(17)ne	Electrical Breakdown V (-90%)	65 p10 Table II
Fiberglass (silicone varnished) Insulation Sheet	3.5(10)	8(16)ne	Tensile strength(-11%) Ultimate Elongation (-97%), Electrical Breakdown V (-7%)	65 p10 Table II Table IV
"	3.1(11)	9(17)ne	Electrical Breakdown V (-90%)	65 p10 Table II
Hermetic Glass in Seal Corp. Connector	7.5(10)	4.8(16) (E>1MEV)	Leak R (-93%) @ 1.8(16)nf	12 p231
Kraftpaper Insulating Sheet	3.3(9)	8(15)ne	Electrical Breakdown V (-17%)	65 p9 Table II
"	3.5(10)	8(16)ne	Electrical Breakdown V (failed), Tensile strength (-100%), Ultimate Elongation (-100%), All parameters failed at this dose	"
Melamine, GP Red 1077-RV22 Melma	1.3(10)		Material became brittle	33 p2, 8
Melamine Formaldehyde in Winchester Connectors	7.5(10)	4.8(16) (E>1Mev)	Leak R (-92.5%) @ 1.8(16)nf	12 p232
Mica (Reconstructed) Silicone Treated Insulating Sheet	3.3(9)	8(15)ne	Tensile strength (-80%), Ultimate Elongation (-80%)	65 p10 Table IV
"	3.1(11)	9(17)ne	No effect on electric breakdown voltage	65 p9 Table II

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Miscellaneous (Cont.)				
Neoprene WRT 45.5% by weight Vulcanizate	1(9)		Compression Set (+38%)	46 p19
"	1(11)		Compression Set(+100%)	"
Phenolic, GP Black #7345 Resinox	1.3(10)		Material becomes brittle	33 p2, 8
Phenolic, GP Black ES 024 03	1.3(10)		Material becomes brittle	33 p2, 7
Phenolic Formaldehyde in Winchester Connectors	7.5(10)	4.8(16) (E>1Mev)	Leak R (-99.2%) @ 1.5(16)nf	12 p229
Polyester Enamel with Oil-modified Phenolic Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (-16%) @ 200°C	63 p7
Polyester Enamel (Modified) with Oil-modified Phenolic Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (+10%) @ 200°C	63 p7
Polyethylene Insulating Sheet	2.5(8)	6(14)ne	Tensile strength (no change), Ultimate Elongation (-24%)	65 p10 Table IV
"	3.5(10)	8(16)ne	Electrical breakdown V (-15%)	65 p9 Table II
"	3.1(11)	9(17)ne	Electrical breakdown V (failed)	"
Polyethylene Disks	1.3(10)		Volume (-0.018%)	13 p19
"	3.1(10)		Thickness 0.025" to 0.125", Diameter 1.33" to 0.55"	13 p22, 24
Polyethylene	1.6(9)		Viscosity increases by factor ~ 10^3, Shore A D. Hardness (+22.5%)	13 p29, 28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Insulation, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Miscellaneous (Cont.)				
Polyethylene Terephthalate Insulating Sheet	3.5(10)	8(16)ne	Tensile strength(-52%) Ultimate elongation = 0% of original, Electrical breakdown V (-14%)	65 p10 Table IV
"	3.1(11)	9(17)ne	Electrical breakdown V = 0% of original	65 p9 Table II
Polyfluoroethyl-Propylene (FEP Teflon) Insulation Sheet	2.5(8)	6(14)ne	Tensile strength(-60%) Ultimate Elongation (-65%)	65 p10 Table IV
"	3.5(10)	8(16)ne	Electric Breakdown V (-94%)	65 p9 Table II
Polytetrafluoroethylene (TFE Teflon) Insulating Sheets	4.7(8)	4(14)ne	Tensile strength & Ultimate Elongation = 0% of original	65 p10 Table IV
"	2.5(8)	6(14)ne	Electric breakdown V (-53%)	65 p9 Table II
"	3.3(9)	8(15)ne	Electric breakdown V = 0% of original	65 p9 Table II
Polytetrafluoroethylene (TFE Teflon) Wiring Insulation	1.3(9)	8.7(11)nf 1(12)nt	Brittle and powdery	8 p117
Polytetrafluoroethylene (TFE) Tubing	4.7(18)	4(14)ne	Breakdown V (-53%)	65 p9 Table III
"	3.4(9)	4.5(15)ne	Breakdown V (failed)	"
Polytetrafluoroethylene Enamel with Silicone Varnish, Magnet Wire Insulation	2.5(9)		Zero thermal life	63 p7
Polyurethane-Fiberglass Insulating Tube	5(11)	5(17)ne	Tensile strength(-40%) Ultimate Elongation (-35%), Electric Breakdown V(-68%)	65 p10 Table V

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Insulation, Electrical	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Miscellaneous (Cont.) Polyvinyl Chloride (PVC) 105°C Tubing	5(11)	5(17)ne	Tensile strength and Ultimate Elongation failed at this dose, Electric Breakdown V (-68%)	65 p10 Table V 65 p9 Table III
Polyvinyl Formal Enamel with no Varnish Magnet Wire Insulation	2.1(10)		Thermal life (-13%)	63 p7
Silicone Enamel with Silicone Varnish, Magnet Wire Insulation	1.3(10)		Thermal life (-11%)	63 p7
Silicone Rubber in Deutsch Connector	7.2(10)	4.8(16) (E>1Mev)	Leak R (-91.6%) @ 9.5(15)nf	12 p230
Silicone LS-53 (Fluorinated Methyl/ Tri-Fluoropropyl) 76.9% by weight	1(9)		Compression Set (+77%)	46 p19
	1(11)		Compression Set (+108%)	"
Silicone Resin-Fiberglass, Insulating Tube	3.4(9)	4(15)ne	Tensile strength (-11%), Ultimate Elongation (-20%)	65 p10 Table V
"	5(11)	5(17)ne	Electric breakdown Voltage (no change)	65 p9 Table III
Viton A (Vinylidene Fluoride/Hexafluoro-propylene Copolymer) 70% by weight	1(9)		Compression Set(+84%)	46 p19
	1(11)		Compression Set (+105%)	"
Silicone Rubber (Extruded) Tubing	3.4(9)	4(15)ne	Tensile strength (-26%), Ultimate Elongation (-62%)	65 p10 Table V
"	3.6(10)	4(16)ne	Electrical Breakdown V (-41%)	65 P9 Table III
"	5(11)	5(17)ne	Breakdown Voltage failed at this dose	"

2.12 **LAMINATES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
American Cyanamid Co				
AC-4232 (Polyester Resin-Glass Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (+1.7%), Tensile strength(+4.2%)	25 p 8
AC-4232 (Polyester Resin-Asbestos Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (+4.5%), Compression Strength (+3.9%)	25 p 8
Coast Mfg. and Supply Co.				
CTL-91LD Laminate	8.3(11)		Tensile Strength (-43%), Compressive Strength (+57%) Flexural Rigidity (+10%)	56 p 19
DC-2106 Plastic Laminate	2.5(11)		Compressive Strength (-25%)	56 p 20
"	8.3(11)		Tensile Strength (-26%), Flexural Strength(-80%)	"
F 120-19 (Phenolic Resin- Asbestos Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (-4.7%)	25 p 8
F120-19 (Phenolic Resin- Glass Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (+28%) Compression Strength (-5.3%)	25 p 8
EPON 828CL Laminate	8.3(11)		Tensile Strength(-57%) Compressive Strength (-50%), Flexural Rigidity (-72%)	56 p 18
LAMINAC 4232 Laminate	8.3(11)		Tensile strength(-30%) Compressive strength (-54%), Flexural strength (-71%)	56 p 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Coast Manufacturing (Cont.)				
Slectron 5003 Laminate	8.3(11)		Tensile strength (No change), compressive strength (-64%) Flexural rigidity (-71%)	56 p 17
Cordo Moulding Pdts.				
Mobiloy AH-81 (Phenolic Resin-Asbestos Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile strength (+ 2.6%) Modulus of Elasticity (-7.7%)	25 p 8
Mobiloy AH-81 (Phenolic Resin-Glass Fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (+5%), Modulus of Elasticity (-5%)	25 p 8
Insulation Mfrs. Corp.				
G-7 Glass Fabric-silicone resin laminate, in boiling dissolver solution of 1 M nitric acid with 75 g/1 of stainless steel metal. Resistant to this solution but suffers 10% weight loss	1(11)		Compressive strength (-29%)	64 p 15
	1(12)		Compressive strength (-72.2%)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Narmco Mfg. Co.				
CONOLON 506 (Phenolic Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (-13.5%) Tensile Strength (+3.4%)	25 p 8
CONOLON 506 (Phenolic Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Modulus of Elasticity (-13.2%), Compression strength (+1.5%)	25 p 8
Shell Development Co.				
EPON 828 (Epoxy Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Compressive strength (+4.3%), Tensile Strength (-4%)	25 p 8
EPON 828 (Epoxy Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (+2.6%) Modulus of Elasticity(-2.5%)	25 p 8
EPON X-131 (Epoxy Resin-asbestos fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Tensile Strength (+5%) Modulus of Elasticity (-2.1%)	25 p 8
EPON X-131 (Epoxy Resin-glass fabric)	9.3(9)	1.2(15) (E>2.9Mev)	Compressive Strength (+8%), Tensile strength (+4.7%)	25 p 8

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Laminates	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Shell, Con't.				
X-131-Plastic Laminate with BF3400	8.3(11)		Tensile strength (-8.3%) Compression strength (-88%), Flexural strength (-75%)	56 p 21
X-131-Plastic laminate with dicyandiamide	8.3(11)		Tensile strength (-22%), Flexural strength (-51%)	56 p 22
Taylor Corp.				
G-7 Glass fabric-silicone resin laminate, In boiling dissolver solution of	1(10)		Impact strength (/27%) Compressive strength (-16%)	64 p 15
1M Nitric acid with 75 g/l stainless steel components. Resistant to this solution but suffers 10% weight loss	1(11)		Inpact strength (60%), Compressive strength (-29%), Volume resistivity decreases factor $\sim 10^8$	"
	1(12)		Impact strength decreases factor $\sim$10	"

2.13 LUBRICANTS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Lubricants	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Hooker Chemical Co.				
Fluorolube (Gyro Fluid)		~1(16) (E>2.9Mev)	Outgassing (0.37 ML gas/ML fluid)	12 p225
Shell Development Co.				
Shell APL grease	2.7(9)	2.9(15) (E>2.9Mev)	Grease apparently Crystallizes	31 p319
Type Hi Temp Jet Oil A, (Complex-ester base) (-45°F to 350°F) Ref. GTO-790	7.4(9)	5.8(14) (E>2.9Mev)	5 change in neutralization No(Mgm KOH/gm) Viscosity (+19%) Flash point (-24%)	44 p55-56
Sinclair Refining Co.				
Turbo S-Oil (L-697) Mil-C-7808C, Sebacate-base fluid, -65°F to 300°F	8.6(9)	5.1(14) (E>2.9Mev)	12.5 change in neutralization No(Mgm KOH/gm) Viscosity (-31%) Flash Point (-23.2%)	44 p55-56

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Lubricants	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Sperry Gyroscope Co.				
Bromotriflouroethylene (Gyro fluid)		~1(16) (E>2.9Mev)	Outgassing (1.6 ML gas/ML fluid)	12 p226
Miscellaneous				
Mil-L-9236A, Substituted-ester base	1(11)		Undergoes 90% decompositon @ 500°F	68 p94
Mil-L-9236B, Substituted-ester base, -65°F to 400°F, Ref. GTO-915 furnished by ASD	1.1(10)	6.3(14) (E>2.9Mev)	7.2 change in neutralization No(Mgm KOH/gm), Viscosity(+19%) Flash Point (-24%)	44 p55-56
4P3E, Bis (Mix-phenoxyphenoxy) Benzene in Gear Test	1(11)		Viscosity changes from 65cs to 10,000cs	68 p74,87
Mixed-4P3E, Mix Bis (Phenoxyphenyl) Ether, 350°F, 3000 psi, Ref. GTO-927, hydraulic Fluid (also for lubrication use)	2.7(10)	3.9(15) (E>2.9Mev)	Viscosity (cs)(+4.75%) +0.145 change in neutralization No. (Mgm KOH/gm), Filtration (particles > 5 μ(Mgm/100 ML)) +14.04, Boiling Range Broadened	50 p21-35
5P4E Mix-Bis (Phenoxyphenoxy) Benzene in gear test	1(11)		Viscosity changes from 400cs to 17000cs @ 600°F. Undergoes 40% decomposition @ 600°F and 50% @ 700°F. Acid No. changes from 0 to 12 (μgm KOH/gm)	68 p68,79, 86

2.14 MAGNETIC MATERIALS

2.14.1 FERRIMAGNETIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferrimagnetic	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Diamonite	3.7(9)		No effect on Dielectric	212 p 4-50
Ferramic Q "permalloy type"	1.1(10)	1(18)nf	Hysteresis Loop flattened considerably	42 Fig. 15
MF3876 Memory Core General Ceramics Corp.	7.7(9)	2(17)ne	Br/Bm % of initial Value (±1%)	15 p65
223MI - Mg, Mn, Fe RCA	1.6(11)	1.2(17) (E>1 Mev)	d Vz (+40%) @ 85°F and 4(14)nf	30 p128-132
226MI- Mg, Mn, Fe, Zn, RCA	1.6(11)	1.2(17) (E>1 Mev)	d Vz (+50%) @ 85°F and 4(14)nf	30 p128 - 132
231 MI - Mg, Mn, Fe, Zn, Cd, RCA	1.6(11)	1.2(17) (E>1 Mev)	d Vz (+20%) @ 85°F and 4(14)nf	30 p128-132
Nickel Ferrite Ni Fe_2 O_4		3(18)nf	Hysteresis Loop flattened considerably	42 Fig. 15
NiZn and MnZn Western Electric	7.7(9)	2(17)ne	Loss of magnetic properties due to temperature heating. No radiation effects damage	15 p63
NXF 0023 - Mg, Mn, Fe, Li, RCA	1.6(11)	1.2(17) (E>1 Mev)	d Vz (+150%) @ 158°F and 3.5(15)nf	30 p128-132
S-5 Memory Core General Ceramics Corp.	7.7(9)	2(17)ne	Br/Bm % of initial value (-7%)@1.2(17)ne	15 p65
Square-Loop Bell Tele. Labs (2 ea)	7.7(9)	2(17)ne	Br/Bm % of initial value (-12%)@1.2(17)ne	15 p65
T-1 (Square Loop Ferrite) fast switching, Telemeter Mag. Inc	1.1(10)	3(18)nf	Hysteresis Loop flattened slightly	42 Fig. 13
T-5 (Square Loop Ferrite) Slower Switching, Telemeter Mag.Inc	1.1(10)	3(18)nf	Hysteresis Loop flattened considerably	42 Fig. 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferrimagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Yttrium Iron Garnet	3.7(9)		Linewidth (+10%) g_{eff} factor does not change, Dielectric constant (<<1%)	212 p4-49
Yttrium Iron Garnet (polycrystalline)	1.1(10)	3(18)nf	Hysteresis Loop flattens considerably	42 Fig. 16
40% Yttrium Iron Garnet - 60% Gadalinium Iron Ferrite	3.7(9)		Linewidth (<1%) g_{eff} factor does not change	212 p4-49
Yttrium Aluminum Garnet Ferrite	3.7(9)		Linewidth (-6%), g_{eff} factor does not change Dielectric Constant (<< 1%)	212 p4-49

2.14 **MAGNETIC MATERIALS**

2.14.2 **FERROMAGNETIC**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetics	DESIGN ALLOWABLES ergs/gm-(C)	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Alfenol (Disordered) 16 Al, Bal. Fe		2(18)nt	60 cps Coercive force (0%), 60 cps Residual Induction (0%), Max. Permeability (-4%), Permeability @ 30 gauss (-4%), negligible effect on normal induction curve and hysteresis loop, no decrease in initial permeability	61 p19, 18, 52, 46
Alfenol (Oriented) 16 Al, Bal. Fe		2(18)nt	Max. permeability (+15%), Permeability @ 20 gauss (+34%), coercive force (-8%), Remanence (+8%), Induction @ 30 Oersteds (-5%), Squareness Ratio (+13%), Remanence @ 60 cps (-2%), Coercive force @ 60 cps (+8%), negligble effect on normal induction curve	61 p18, 19, 45
Carbonyl Iron E (Glass Binder) 98.5 Fe, Bal. C,N,O		2(18)nt	Eddy I loss coefficient (-40%), Core loss factor (+16.7%), Permeability (No change)	61 p20
Carbonyl Iron E (Plastic Binder) 98.5 Fe, Bal. C,N,O		2(18)nt	Permeability (no change) Eddy I loss coefficient (+25%), Core loss factor (-28.6%)	61 p20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagnetics	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm^2		
Deltamax Arnold Eng. Corp.	7.7(9)	2(17)ne	Br/Bm % of initial value (-9%) @ 1.2 (17)ne	15 p65
Flakenol, Sendust Flake, 5.5 Al, 9.5 Si, Bal. Fe		2(18)nt	Permeability (+11.4 %), hysteresis loss coefficient (+10%), Eddy I loss coefficient (+500%), Residual loss coefficient (+88.9%), Core loss factor (+100%)	61 p20
2-81 Mo Permalloy, Pressed Powder, 2 Mo, 81 Ni, Bal. Fe		2(18)nt	Permeability (< 1%), Hysteresis loss coefficient (-33%), Eddy I loss coefficient (+100%), Residual loss coefficient (0%), Core loss factor (+100%)	61 p20
4-79 Mo Permalloy 4 Mo, 79 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-89%), Max. permeability (-79%) Coercive force (+403%), Coercive force @ 60 cps(+110%) Remanence (-44%) Remanence @ 60 cps (-51%), Induction @ 30 Oersteds (+1%), Squareness Ratio (-44%), Normal induction curve @ 0.2 oersteds (-60%), Initial permeability (-91%)	61 p18, 19, 28, 52
4-79 Mo Permalloy Arnold Eng. Corp. (2 ea)	7.7(9)	2(17)ne	Br/Bm % of Initial Value (no change) Coercive force increased factor of 4	15 p69
4-79 Mo Permalloy Arnold Eng. Corp.(2ea)	7.7(9)	2(17)ne	Br/Bm % of initial value (-46%)	15 p65

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials Ferromagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Mumetal 5 Cu, 2 Cr, 77 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-65%), Max. permeability (-38%), Coercive force (+158%), Coercive force @ 60 cps (+35%), Remanence (-26%), Remanence @ 60 cps (-16%), Induction @ 30 Oersteds (-3%), Squareness Ratio (-23%), Initial permeability (-74%), Normal induction curve @ 0.2 Oersteds (+8.8%)	61 p18, 19, 31, 52
Nickel Ferrite $NiO \cdot Fe_2O_3$		2(18)nt	Permeability (no change), hysteresis loss coefficient (-11%), Core loss factor (-44%)	61 p20
48 Nickel-Iron 48 Ni, Bal Fe		2(18)nt	Permeability @ 20 gauss (-70%), Max. permeability (-10%), Coercive force(+99%), Coercive force @ 60 cps (+35%), Remanence (-26%), Remanence @ 60 cps (-33%), Induction @ 40 Oersteds (-2%), Squareness ratio (-26%), Initial permeability(-75%), Normal induction curve @ 0.2 Oersteds (-36%)	61 p18, 19, 34, 52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Ferromagentic	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Orthonol, 50 Nickel-Iron, 50 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-31%), Max. permeability (+15%), Coercive force (-28%), Coercive force @ 60 cps (+44%), Remanence (-24%), Remanence @ 60 cps (-20%), Induction @ 30 oersteds (-4%), Squareness ratio (-21%), Initial permeability (-37%), Normal induction curve @ 0.2 oersteds (-7.9%)	61 p18, 19, 35, 52
2 V Permendur, 2 V, 49 Co, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+3%), Max. permeability (+2%), Coercive force (-2%) Coercive force @ 60 cps (+5%), Remanence (-1%), Remanence @ 60 cps (-6%), Induction @ 30 oersteds (-1%), Squareness ratio (0%), Initial permeability (0%), Normal induction curve @ 0.2 oersteds (no effect)	61 p18, 19, 48, 52
3-1 Silicon-Aluminum-Iron, 3 Si, 1 Al, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+1%), Max. permeability (+1%), Coercive force (-2%), Coercive force @ 60 cps (0%), Remanence (-1%), Remanence @ 60 cps (0%), Induction @ 30 oersteds (-1%), Squareness ratio (0%), Initial permeability (0%), No effect on normal induction curve or hysteresis loop	61 p18, 19, 43, 44, 52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT **Magnetic Materials, Ferromagnetic**	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
3 Silicon-Iron (Oriented) 3 Si, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+18%), Max. permeability (+1%), Coercive force (-2%) Coercive force @ 60 cps (0%), Remanence (-3%), Remanence @ 60 cps (0%), Induction @ 30 oersteds (-1%), Squareness ratio (-1%), Initial permeability (0%), No effect on normal induction curve or hysteresis loop	61 p18, 19, 41, 42, 52
3.5 Silicon-Iron 3.5 Si, Bal. Fe		2(18)nt	Permeability @ 20 gauss (+8%), Max. permeability (-1%), Coercive force (+6%) Coercive force @ 60 cps (+9%), Remanence (+1%), Remanence @ 60 cps (+2%), Induction @ 30 oersteds (0 %), Squareness ratio (+1%), No effect on normal induction curve	61 p18, 19, 40
Supermalloy 50 Mo, 79 Ni, Bal. Fe		2(18)nt	Permeability @ 20 gauss (-93%), Max. permeability (-93%) Coercive force(+815%) Coercive force @ 60 cps (+1000%), Remanence (-38%), Remanence @ 60 cps(-46%) Induction @ 30 oersteds (-3%), Squareness ratio (-36%), Initial permeability (-98%)	61 p18, 19, 52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials Ferromagnetic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Supermalloy Arnold Eng. Corp. (2 ea)	7.7(9)	2(17)ne	Permeability (-55%) also other changes	15 p69
Supermendur Arnold Eng. Corp.	7.7(9)	2(17)ne	Br/Bm % of initial value (+4%) @ 4(16)ne	15 p65

2.14 MAGNETIC MATERIALS

2.14.3 PERMANENT MAGNETS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Alnico II		5(20) (E>0.025ev)	4% decrease in open circuit induction	66 Fig. 1
"		1(20)ne	Change in open magnetic circuit induction: -2% @ 60°C -3% @ 235°C & 325°C	59 p77
"		2(18)ne	No change in demagnetization curve	59 p28
Alnico IIA		2(19)ne	Open magnetic circuit induction change: -5% @ 3(18)ne -2% @ 2(19)ne	59 p19
Alnico V		5(20) (E>0.025ev)	1 % decrease in open circuit induction	66 Fig. 1
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds) (-10%) B(K gauss)(+1.4%) @ 500°C	59 p25
"		1(20)ne	Open magnetic circuit induction change: -2.5% @ 60°C -1% @ 235°C +1% @ 325°C	59 p17
Alnico VC		2(19)ne	Open magnetic circuit induction change: -9% @ 3(18)ne -3.5% @ 2(19)ne	59 p19
Alnico XII		2(19)ne	Open magnetic circuit induction change: -1.5% @ 3(18)ne -2% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: -6.5% @ 60°C -4.5% @ 235°C -1.5% @ 325°C	59 p17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Alnico XII		2(18)ne	Demagnetization Curve intercepts change: H(oersteds)(-2.5%) B(Kguass)no change @ 500°C	59 p2
"		5(20) (E>0.025ev)	1% decrease in open circuit induction	66 Fig. 1
Barium Ferrite (Oriented)		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-2.5%) B(K gauss)(-2.6%)	59 p26
"		2(19)ne	Open magnetic circuit induction change: -3% @ 3(18)ne 8% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: -63% @ 60°C -24.5% @ 235°C -24% @ 325°C	59 p17
"		5(20) (E>0.025ev)	24% decrease in open circuit induction	66 Fig. 1
Barium Ferrite (Unoriented)		2(19)ne	Open magnetic circuit induction change: -3% @ 3(18)ne -8% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: -54.5% @ 60°C -21% @ 235°C ~ 0 @ 325°C	59 p17
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-9.2%) B(K gauss)(no change)	59 p26
"		5(20) (E>0.025ev)	24% decrease in open circuit induction	66 Fig. 1

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT **Magnetic Materials, Permanent Magnets**	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
$3\frac{1}{2}$ Chromium Steel		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-71.4%) B(K gauss)(-40%) @ 500°C	59 p27
"		1(20)ne	Open magnetic circuit induction change: +2.5% @ 60°C -68% @ 235°C -66.5% @ 325°C	59 p17
"		2(19)ne	Open magnetic circuit induction change: -8% @ 2(18)ne -4.5% @ 2(19)ne	59 p19
36 Cobalt Steel		2(19)ne	Open magnetic circuit induction change: -30.5% @ 3(18)ne -9% @ 2(19)ne	59 p19
"		1(20)ne	Open Magnetic circuit induction change: -37% @ 60°C -37.5% @ 235°C -34.5% @ 325°C	59 p17
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-62.5%) B(K gauss)(-36.3%) @ 500°C	59 p25
"		5(20) (E>0.025ev)	40% decrease in open circuit induction	66 Fig. 1
Cunico I		2(19)ne	Open magnetic circuit induction change: -5.5% @ 3(18)ne -1.5% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: -7.5% @ 60°C -4.5% @ 235°C -8.5% @ 325°C	59 p17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT **Magnetic Materials, Permanent Magnets**	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Cunico I		2(18)ne	Demagnetization Curve intercepts change: H(oersteds)(-8.75%) B(Kgauss)(-.5%) @ 500°C	59 p25
"		5(20) (E>0.025ev)	8% decrease in open circuit induction	66 Fig. 1
Cunife I		2(19)ne	Open magnetic circuit induction change: -45.5% @ 3(18)ne -1.5% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: +13% @ 60°C -52.5% @ 235°C -92% @ 325°C	59 p17
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-3.8%) B(Kgauss)(-1.8%)	59 p25
"		5(20) (E>0.025ev)	97% decrease in open circuit induction	66 Fig. 1
ESD Fine Iron		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-5%) B(Kgauss)(-4.7%)@500°C	59 p27
"		2(19)ne	Open magnetic circuit induction change: -3.5% @ 3(18)ne -2% @ 2(19)ne	59 p19
ESD Fine Iron Cobalt		3(18)ne	Open magnetic circuit induction change: (-6.5%)	59 p19
"		2(18)ne	Demagnetization curve induction change: H(oersteds)(-25.7%) B(Kgauss)(-7.7%)	59 p28

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Magnetic Materials, Permanent Magnets	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Platinum Cobalt		2(18)ne	Demagnetization curve intercepts change: H(oersteds)(-2.7%) B(Kgauss)(-4%)@500°C	59 p26
"		5(20) (E>0.025ev)	67% decrease in open circuit induction	66 Fig. 1
"		2(19)ne	Open magnetic circuit induction change: (-12%)	59 p17
"		1(20)ne	Open magnetic circuit induction change: -38% @ 235°C -40% @ 325°C	59 p17
Silmanal		2(19)ne	Open magnetic circuit induction change: -10% @ 3(18)ne +5.5% @ 2(19)ne	59 p19
"		1(20)ne	Open magnetic circuit induction change: -46.5% @ 60°C -72.5% @ 235°C -93.5% @ 325°C	59 p17
"		2(18)ne	Demagnetization curve intercepts change: H(oersteds) (-60%) B(Kgauss)(-50%) @ 500°C	59 p26
"		5(20) (E>0.025ev)	95% decrease in open circuit induction	66 Fig. 1

2.15 **MOTORS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Motors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Diehl Manufacturing Co.				
60 cps, 2-pole, 2-phase FPE216 Servo-motor (1 ea)	1.5(11)	1.1(17) (E>1 Mev)	Failed @ 8.7(16) nf	30 p 152-157
Electric Indicator Co., Inc.				
Hysteresis Synchronous Motor, Class H insulation, 115 v @ 60cps with CAL Research #159 grease, Type AL4541 (1 ea)	6.6(10)		Much of the original power was lost	71 p 6, 13, 16
Inland Motor Corp.				
T2139C, DC Torquer Motor (1 ea)	1.6(10)	1.2(15) (E>2.9Mev)	Apparent Torquer Load (oz-inch) increases from zero to ~ 1	12 p 69
Lear-Siegler, Inc.				
D. C. Actuator Motor (1 ea)	2.7(9)	2.9(15) (E>0.3 Mev)	APL grease failed	31 p 276-319

2.16 O-RINGS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT O-Rings	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	$\frac{n}{cm^2}$		
Alleghany Plastic				
Teflon X	5(6)		Weight Change(-0.01%)	8 p 125
Dupont Co.				
Teflon Back-up Ring	1.3(9)		Brittle	47 p 80
Linear, Inc.				
Copolymer XP-9-13	5 (6)		Shore Durometer Hardness(-1%)	8 p 125
XWT-15T (Experimental Compound Viton A-Asbestos)	4.9(9)		Performance satisfactory	47 p 80
Precision Rubber Products				
Compound 1387 (Oil-Resistant)	1(11)		Hardness(+38%) Tensile (+ 110%) Elongation (-91%) Flat bend (Broke)	Technical Bulletin from PRP
Compound 4387 (Non-oil Resistant)	1(11)		Hardness (+41%) Elongation (-97%) Tensile (-20%) Flat bend (Broke)	"
Compound 1700 (Viton A)	4.9(9)		Failed-hardened and Leaked Tensile (-20%)	47 p 80

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT O-Rings	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Miscellaneous				
Acrylonitrile TDXE-121 #72 (2ea)	5 (6)		Weight(+1.08%) Shore Durometer hardness (-2%)	8 p 125
Acrylonitrile TDXE-35 #74 (2 ea)	5(6)		Weight Change(+1.16%) Shore Durometer hardness (-10%)	8 p 125
Buna-N	3.1(9)		Hardened but kept seal	47 p 42, 80
En-Jay Butyl XI-351 (2 ea)	5(6)		Weight (-0.09%) Shore Durometer Hardness (+ 2%)	8 p 125
KEL-F Poppet	1.1(10)		Crystallized Brittle and Cracked	8 p 88
Leather Backup Ring	1.3(9)		No damage	47 p 42, 80
Neoprene #72 Compound (2 ea)	5(6)		Weight (+1.009%) Shore Durometer Hardness (0.0%)	8 p 125
Neoprene #74 Compound (2 ea)	5(6)		Weight (+ 1.007%)	8 p 125
Parco 805 (Butyl Rubber)	1.1(10)		Melted (Not Rec. For Nuc. Use)	8 p88
Parker B-496-7 (2 ea)	5(6)		Weight (+ 1%) Shore Durometer Hardness (-10%)	8 p 125

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT O-Rings	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Miscellaneous Con't				
Rubber 366YV (2 ea)	5 (6)		Weight (-0.85%) Shore Durometer Hardness (-9%)	8 p 125
Rubber 524A (2 ea)	5(6)		Weight (+1%) Shore Durometer Hardness (+4%)	8 p 125
50% Teflon loaded XIT 351 (2 ea)	5(6)		Weight (+ 0.04%) Shore Durometer Hardness (-3%)	8 p 125
Teflon (TFE)	1.1(10)		Shredded, Brittle	8 p 88

2.17 POTENTIOMETERS

2.17.1 CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potentiometers, Carbon Composition	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Allen-Bradley				
0-0.1K ± 10% at 120°C RV4LAYSA101A (6 ea)	4.5(10)	6.3(13)nf 2.4(15)ne	Max R (-1.2%) at 9.2(12)nf, Min R (-72%) at 4.9(13)nf	2 p.216, 218
0-25K (Molded) RV6LAXSA253A (6ea)	1.6(11)	4(16) (E>0.5MEV)	Max R(+12%) at 1.5(6) nf, Contract ArmR(< 1%)	35 p. 10.41-59
0-100K ± 10% at 120°C RV4LAYSA104A (3ea)	4.5(10)	6.3(13)nf	Max R(-3.1%) at 1.3 (15)ne, Min R(+61%) at 2.3(15) ne	2 p.216, 221
0-250K (Molded) RV6LAXSA254A (6ea)	1.6(11)	4(16) (E>0.5MEV)	MaxR(+8.3%)at~1(16) nf, Contact Arm R(<1%)	35 p.10.41-59
0-1 Meg ± 10% at120°C RV4LAYSA105A (6ea)	3.5(10)	1.1(15)ne 3.7(13)nf	MaxR(-4.1%) at 2.6 (14) ne, MinR(+ 35%) at 5.2(14)ne	2 p.216, 223
Chicago Telephone Supply Corp.				
0-50K (Film Type) RV5LAXSB503A (6ea)	1.6(11)	4(16) (E > 0.5MEV)	Max R(-23%)at 2.3(16) nf, contact R (< 1%)	35 p.10. 41-59
0-500K (Film Type) RV5LAXSB504A (6ea)	"	"	Max R(-19%) Contact R (< 1%)	"
0-2.5 Meg (Film Type) RV5LAXSD255B (6 ea)	"	"	Max R (-24%) Contact R (< 1%)	"

2.17 POTENTIOMETERS

2.17.2 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potentiometers, Wire-wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Bourns Labs, Inc.				
0-0.5K, Trim-pot 3040-W-1-501 (6ea)	1.3(11)	5.1 (16) (E>1 MEV)	Resistance (+0.85%) at 2(14)nf, one opened	30 p. 190-202
0-20K ± 10%, Trim-pot 220-W-1-203 (1ea)	6.3(10)	4.3(16) (E>1 MEV)	MaxR(+ 1.5%) at 8.6 (13)nf	12 p. 165
0-20K, Trim-pot 3040-W-1-203 (6 ea)	1.3(11)	5.1(16) (E>1 MEV)	Resistance (+ 0.1%) at 3(15)nf	30 p. 190-202
Chicago Telephone Supply Corp.				
0-15K ± 5% RA 30A1SD153AJ (6ea)	2.5 (10)	6.1(14)ne 3.6(13)nf	Max R (+0.008%) at 3(14)ne, Min R(-19%) at 3.1(13)ne	2 p. 209, 212
Hadley Co. Inc, Robert M.				
0-0.5K ± 5%, 1/2W, Temp Coeff ± 20ppm/°C	7.2(10)	4.8(16) (E>1MEV)	Max R (+ 4.78%) at 1.4(15)nf	12 p. 180 11 p. 11
Trimpot, 500 TP (1ea)				
P.R. Mallory and Co.				
0-5K, ± 5% RA15A1SD502AJ (6ea)	2.5(10)	1.4(15)ne 3.6(13)nf	Max R (+3.3%) at 1.2 (15)ne, MinR(-26%) at 5.7 (13)ne	2 p. 209, 210

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potentiometer, Wire-Wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Ohmite Mfg. Co.				
0-10Ω ± 10% RP101SJ100KK (12 ea)	3.2(10)	1.4(15)ne	MaxR(+ 13.1%) at 3.5 (14)ne	2 p.194, 196-199
0-100Ω ± 10% RP101SJ101KK (6ea)	5.1(10)	3.7(15)ne	Max R (+ 1.15%) at 1.4(15)ne	2 p.194, 200-201
0-1K ± 10% RP101SJ102KK (9ea)	3.8(10)	1.7(15)ne	MaxR (+ 3.7%) at 1(15)ne	2 p.194, 202-204
0-5K ± 10% RP101SJ502KK (6ea)	5.1(10)	3.7(15)ne	MaxR (+ 1.1%) at 1.9 (15)ne	2 p.194, 205-207

2.18 **POTTING COMPOUNDS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potting Compounds	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
American Latex Fibre Corp.				
Stay Foam AA-402 (2 ea)	2(8)	1.5(15) (E>0.1Mev)	Resistance Ratio Ro/R = 31, Volume (+15.4%)	10 p151
Dennis Chemical Co.				
Insulating Lacquer 1162 A/B (2 ea)	"	"	Resistance Ratio Ro/R = 38 Volume (+1.4%)	10 p149
Dow Corning Corp.				
RTV-501 (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 18 Volume (+16%) changed from tan to grey	10 p147
Emerson & Cuming, Inc.				
Conducting Epoxy 57C	1.9(10)	1.5(15) (E>2.9Mev)	Resistance (+1.03%) @ 9.2(12)nf	12 p239
Stycast 2651 MM (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 3.3 Volume (-0.58%)	10 p146

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potting Compounds	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
General Electric Co.				
Silicone Rubber RTV-90	1.3(9)	8.7(11)nf 1(12)nt	Good condition but less pliable	8 p117
Hysol Corp.				
#12.007 (2 ea)	2(8)	1.5(15) (E>0.1Mev)	R. Ratio Ro/R = 1.3 No volume change	10 p150
Mica Corp.				
EG758T (2 ea)	2(8)	1.5(15) (E>0.1Mev)	R. Ratio Ro/R = 450 Volume (+6.9%), darkened	10 p152
Minnesota Mining & Mfg. Co.				
Scotchcast #3 (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 2.7 Volume (+0.89%)	10 p146
Scotchcast foam Resin #603 (2 ea)	"	"	R. Ratio Ro/R = 170	10 p154

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Potting Compounds	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Products Research Co.				
Polysulfide Rubber PR-1201-Q	1.3(9)	8.7(11)nf 1(12)nt	Good Condition	8 p117
Shell Chemical Co.				
EPON 828 Cat. D (2 ea)	5(8)	3.3(15) (E>0.1Mev)	R. Ratio Ro/R = 2.7 Volume (+1.3%), Darkened	10 p148

2.19 **PRINTED CIRCUITS**

2.19.1 **ASSEMBLIES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuits (Assemblies)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm^2		
Aerovox Corp.				
Type PA-95 consisting of a resistor and a capacitor (6 ea)	4.9(10)	2.8(15)ne	Resistance (+10.8%) capacitance (-46%) No effect on board.	2 p. 796
Centralab Division				
Type PC-33 with resistor and capacitor (6 ea)	4.9(10)	2.8(15)ne	Resistance (-13.8%) Capacitance (-31%) No Effect on Board.	2 p. 796

2.19 PRINTED CIRCUITS

2.19.2 BOARDS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit, Boards	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Centralab Division				
Steatite Type (Uncoated) (3 ea)	5.5 (10)	3.6(15)ne	Capacitance between leads (+ 3.3%)	2 p. 776, 793
(Acrylic Coated)(3ea)	"	"	Capacitance between leads (+ 2%) Some permanent effects on both types	"
Chance Vought Corp.				
Copper-clad fiberglass Melamine (2.5" x 4") following coatings were used: (1) Nitro-cellulose lacquer	2.1(8)		Leakage I increased by factor 1(3) at 2.6(7) ergs/gm-(C)	14 p. 3, 6
(2) Silicone Varnish (DC 997)			Leakage I increased by factor 1(5) at 2.6(7)e/g-(c) at 70°c Breakdown V(-30%)	14 p. 3, 10
(3) Epoxy - polyamid			Leakage I increased by factor 1(4) at 2.6(7)e/g-(c) at 70°c Breakdown V(-20%)	14 p. 3, 10
(4) Polyester catalyzed with methyl ethyl ketone (MEK) peroxide			Leakage I increased by factor ~1(3) at 2.6(7)e/g-(c) at 70°c Breakdown V(-25%) Superior coating of those tested.	14 p. 3, 10
(5) Uncoated			Leakage I increased by factor ~1(5) at 2.6(7) ergs/gm-(C) Breakdown V (0.0%)	14 p. 3, 10

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit, Boards	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Continental Connector Corp.				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor 1(4) at 1.2(14)ne and 1.7 (9)e/g-(c) corroded, and blistered.	2 p. 782, 776
(Acrylic Coated) (2ea)	"	"	Insulation resistance decreased by factor 1(3) at 2.8(15) ne and 4.3 (10)ergs/gm-(C) corroded and blistered.	"
Glass Melamine Type	5.5(10)	3.6(15)ne	Copper corroded, 1 lead opened, capacitance between leads (≠ 14%)	2 p. 776, 785
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance between leads (-5%), No Physical damage but leads easily removed from board	2 p. 776, 792-794
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance between Leads (≠ 7.7%), Boards were extremely Brittle	2 P. 776, 787
Teflon Type	5.5(10)	3.6(15)ne	Board was destroyed by radiation	2 p. 776, 791

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit Boards	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>Formica Corp. Subs. American Cyanamid Co.</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (0%) Copper Strips corroded	2p.776, 786
Paper Phenolic Type 36	5.5(10)	3.6(15)ne	Capacitance (/24.7%) Boards were extremely Brittle	2 p. 776, 788
<u>General Electric Co.</u>				
Paper Phenolic Type-XXXP	5.5(10)	3.6(15)ne	Capacitance (/14.%), Boards were Extremely Brittle, 1 Lead opened	2 p. 776, 788
<u>Mica Corp.</u>				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (/ 40%) Copper Strip Corroded	2 p. 776, 786
Paper Phenolic Type-6038	5.5(10)	3.6(15)ne	Capacitance (/16.5%) Boards Extremely Brittle	2 p. 776, 788

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit Boards	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
New England Electronic Component, Inc.				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor 1(14) @ 3.2(15)ne & 3.3(10)ergs/gm-(C) Blistered & Warped	2 p776,781
(Acrylic Coating) (2 ea)			Insulation resistance decreased by factor 1(4) @ 3.2(15)ne & 3.3(10)ergs/gm-(C) Blistered & Warped	
Paper Phenolic Type XXXP230	5.5(10)	3.6(15)ne	Capacitance (+30%), Boards extremely brittle	2 p776,788
Richardson Company				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (+12.5%), Badly corroded	2 p776,786
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance (+12.1%), Extremely brittle, 1 broke by normal handling	2 p776,788

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit Boards	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Synthane Corporation				
Glass Epoxy Type (Uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor ~1(4) @ 2.9(15)ne & 4.3(10)ergs/gm-(C) Strips corroded, No other damage	2 p776,782
(Acrylic Coating) (2 ea)	"	"	Insulation resistance decreased by factor ~1(4) @ 3.2(15)ne & 3.3(10)e/g-(C), No physical damage	"
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (+10%), Corroded strips, Extremely brittle	2 p776,786
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance (+21%), No physical damage, Copper strips easily removed	2 p776,791
Paper Phenolic Type XXXP	5.5(10)	3.6(15)ne	Capacitance (+17%), Extremely brittle	2 p776,787
Taylor Fibre Company				
Glass Epoxy Type (uncoated) (2 ea)	5.5(10)	3.6(15)ne	Insulation resistance decreased by factor ~1(4) immediately, Blistered & Warped	2 p776,781
(Acrylic Coating) (2 ea)	"	"	Insulation resistance decreased by factor ~1(3) @ e.2(15)ne & 3.3(10)ergs/gm-(C) Blistered & Warped	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Printed Circuit Boards	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Taylor Fibre Company(Cont.)				
Glass Melamine Type	5.5(10)	3.6(15)ne	Capacitance (-60%), Corroded, Extremely brittle	2 p776,786
Nylon Phenolic Type	5.5(10)	3.6(15)ne	Capacitance (+16%), No physical damage, Copper strips loose	2 p776,791
Paper Phenolic Type XXXP242	5.5(10)	3.6(15)ne	Capacitance (+27%), Extremely brittle	2 p776,788
Miscellaneous				
Flourcarbon Type	5.5(10)	3.6(15)ne	Boards melted in-pile due to radiation	2 p792

2.20 **PROTECTIVE COATINGS**

2.20.1 **ENAMELS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Enamels)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Type I, white Enamel MIL-E-7729	1(11)		Change of 5% in reflectance, a marked decrease in adhesion, a marked increase in abrasion resistance	73 p. 17
Type I, Red Enamel MIL-E-7729	7(10)		A change in color, a slight decrease in adhesion, decrease in corrosion resistance.	73 p. 17
Type I, Black Enamel, MIL-E-7729	7(10)		A decrease in adhesion, improved flexibility. No effects were noted at 1 (10) ergs/gm-(C)	73 p. 17
Drying Oil Alkyd Enamel Type 1 MIL-E-7729	1(11)		Very good resistance to radiation. Further Irradiation would seriously degrade this material	73 p. 17
Glyceryl Pthalate Alkyd Enamel, Type I, MIL-E-5557	1(11)		Very good resistance to radiation	73 p. 17

2.20 PROTECTIVE COATINGS

2.20.2 FINISHES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Finishes)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Phenolic (A Phenol-formaldehyde thermosetting resin colored by a blue organic dye.) MIL-C-3043 Blue	1 (11)		This dose was slightly harmful at 250°F but improved the coating at 500°F. At 500°F the humidity resistance and film condition improved.	73 p. 18
Epoxy Coatings MIL-C-4456 (USAF) Blue - Gray	1 (11)		Increased Irradiation caused a decrease in humidity resistance, adhesion, reflectance for the unbaked samples. For the baked samples, adhesion, abrasion resistance, humidity resistance, flexibility, and film properties decreased; the color changed also.	73 p. 19
Silicone - Alkyds MIL-E-25606(USAF)	1 (10)		Little Effect	73 p. 19
White (Plaskon St-873 resin)	5 (11)		Large decrease in reflectance, adhesion, and film condition. A large increase in abrasion resistance.	73 p. 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Finishes)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Nitrocellulose Lacquer MIL-L-7178	7 (10) 5 (10)		Moderate degradation. Appears to be the upper limit of usefullness.	73 p. 20
Phenolic Coating MIL-R-3043	1 (11)		Excellent resistance to radiation and heat	73 p. 21

2.20 PROTECTIVE COATINGS

2.20.3 FLUORINATED VINYLS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Fluorinated Vinyls)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm²		
M. W. Kellogg Co.				
Fluorinated vinyl Lacquer, aluminized,	1 (11)		Unbaked samples showed greatly increased abrasion resistance and apparent adhesion.	73 p. 19
"	5 (11)		Decreased abrasion resistance and apparent adhesion due to flaking of the film.	73 p. 19
"	1 (11)		Baked samples decreased apparent adhesion and increased abrasion resistance	73 p. 19
"	5 (11)		Greatly decreased apparent adhesion, abrasion resistance, and flexibility	73 p. 19
Fluorinated Vinyl Lacquer, aluminized KEL-F-800	5 (11)		This material has poor resistance to radiation. At 1(11) there was moderate degradation at 75°F and 250°F. Degradation was severe at 5 (11) at 75°F and 250°F.	73 p. 21

2.20 **PROTECTIVE COATINGS**

2.20.4 LACQUERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Protective Coatings (Lacquers)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
White Nitrocellulose Lacquer, MIL-L-7178	1 (11)		A marked yellowing (27% change in reflectance), an increase in adhesion and humidity resistance, a decrease in flexibility, abrasion resistance, gloss, and film condition.	73 p. 17
Red nitrocellulose Lacquer, Mil-L-7178	1 (11)		A noticeable darkening increase in adhesion and abrasion resistance decrease in flexibility, gloss, and film condition.	73 p. 17
Black nitrocellulose Lacquer, MIL-L-7178	1 (11)		Increased adhesion, abrasion resistance, humidity resistance, and a loss of gloss.	73 p. 17
			N. B. Irradiations of 7 (10) embrittled the lacquers, increased blistering in humidity. No effect was noted at 1 (10)ergs/gm-(C)	73 p. 17

2.21 **RELAYS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Allied Control Co., Inc.				
Type MH-180 hermetically sealed (4 ea)	4.46(10)	4.38(12) (E>2.9MEV)	CoilR(≠7.3%) at 1.38(11)nf, Drop out current- erratic	21 p.35, 66
Branson Corp.				
Time Delay, 6.3v heater 2P2T, 115V Type MTRH-3127 (1ea)		6.3(16) (E>0.5MEV)	No damage to Relay operation	35 p.6.55, 10.127
C.P. Clare and Co.				
Telephone Type (uncovered) A29634 (4ea)	4.3(10)	3.3(12) (E>2.9MEV)	Coil R(≠ 2.87%) at 1.06(11)nf, Drop-out current (≠ 3.26%)	21 p.37, 68
General Electric Co.				
ZL176 Magnet wire (Basically Formex) Type FB 100Y1 (3 ea)	7.8 (8)	5.1(15) (E>0.1MEV)	Coil R(≠3.54%) at 1.4(15)nf, contact R(≠ 12%)	10 p.16, 131
TFE Teflon wire Type FB100Y2 (3 ea)	8.8(8)	5.7(15) (E>0.1MEV)	Coil R (≠ 5.9%) at 4.2(15)nf, contact R(12.5%)	10 p.16, 132
ML Enamel Magnet Wire Type FB100Y3 (3 ea)	9.7(8)	6.1(15) (E>0.1MEV)	Coil R (≠ 5.5%) at 5.1(15)nf, Contact R (12.5%)	10 p.16, 133

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Hartman Electrical Manufacturing				
Power Contractor Coil: 28VDC Contacts: 200VAC, 400cps Type BH-138AH (1ea)	3(10)	1.7(16) (E > 1MEV)	Satisfactory operation throughout test. Contact operation o.k.	30 p. 183
Hathaway Electronics Inc.				
Dri-reed relay Series M-Form A (1ea)	6.7(10)	5.3(16) (E>0.3MEV)	Normal operation throughout test	31 p. 190
Potter and Brumfield Inc.				
DPDT 2A at 30 VDC Type PBSC11DA (3ea)	1.1(9)	6.5(15) (E>0.1MEV)	Coil R (± 4.5%) at 2.3(15)nf, Contact R (±45%) at 2.3(15)nf	10 p. 16, 134
SP2T, 2A, 1.8K, 65mw Coil, 500V(RMS) PW Type (2 ea)		6.1(15) (E>0.5MEV)	Contact resistance increased, contacts were pitted and black; not rec. for Hi-I or low Signal application in Nuc. Environment	35 p. 10.119-124
General Purpose Uncovered Type SP11D (4 ea)	5.4(10)	4.5(12) (E>2.9MEV)	Coil R (± 7.9%) at 1.42(11) nf Drop-out I (± 3.85%)	21 p. 33, 64

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	 $\frac{\text{n}}{\text{cm}^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Potter and Brumfield Con't				
Midget, Hermetically Sealed, Type SM5DS (4 ea)	5.5(10)	4.9(12) (E>2.9MEV)	Coil R (+ 7.8%) at 1.56(11)nf Drop-out I (+ 13.4%)	21 p. 36, 67
2 PST - N.O., 28VDC 5.6 ma, 5K Type MH (4 ea)		1.2(17) (E>0.5MEV)	Pull-in V (+30%) Drop-out V (±20%) Satisfactory operation	35 p. 10.124-127
Price Electric Co.				
Rotary (uncovered) Type 76-3 (4 ea)	7.6(10)	6.1(12) (E>2.9MEV)	Coil R (+ 7.37%) at 1.93(11)nf	21 p. 39
26VDC, Selenoid type Hermetically sealed KB part # 300R022 (3 ea)	3.7(10) 5.7(9)	2.2(14)nf 1.7(16)nf (E>0.5Mev)	Pull-in, drop-out Time, current and voltage all remained within specification	4 p. 16-35

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Relays	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sigma Instruments, Inc.				
Midget Hermetically Sealed Type 22 RJC-200G (4ea)	6.9(10)	6(12) (E>2.9MEV)	Coil R (+8%) @ 2(11)nf Drop-out I (+5.7%) at 1.1(12)nf	21 p. 38, 69
Sensitive Aircraft Type Hermetically Sealed Type 5 RJ-20006 (4ea)	5.5(10)	4.5(12) (E>2.9MEV)	CoilR(+ 6.9%) at 1.42(11)nf, Drop-out I (+7.5%) at 3.7(12) nf	21 p. 31, 62
Sensitive Aircraft Type Type 5R-20006 (4ea)	9.9(10)	7.6(12) (E>2.9Mev)	Coil R(+7.6%) at 2.4 (11)nf, Drop-out I (+ 3.85%)	21 p. 33, 64
Western Electric				
Mercury-wetted contacts Hermetically sealed Type 275C (4ea)	5.4(10)	4.5(12) (E>2.9Mev)	Coil R(+7.7%) at 1.5 (11)nf Drop-out I (+3.95%)	21 p. 34, 65
Westinghouse Air Brake Co.				
26.5VDC, Hermetic #312587-002 (4ea)	3.9(10) 5.5(9)	2.3(14)nf 1.7(16)nf (E>0.5Mev)	Satisfactory operation, 1coil opened	4 p. 16-35

2.22 RESISTORS

2.22.1 BORON-CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Boron-Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
International Resistance Co.				
0.1K $\pm$1%, 2W Type BOH, RN30 (12 ea)	2.4(10)	5.1(15) (E>2.9Mev)	Resistance(-0.2%)	23p 19, 48
10K$\pm$1%, 2W Type BOH, RN30 (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	No Resistance change	22p 3, 31
10K$\pm$1%, 2W Type BOH, RN30 (12 ea)	2.4(10)	5.1(15) (E>2.9Mev)	Resistance(+0.6%)	23p 19. 48

2.22 **RESISTORS**

2.22.2 BORON-CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Boron-Carbon Film	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Corning Glass Works				
4.65K+1% RN25R4631F (7 ea)	2.6(10)	1.4(15)ne 9.0 (17)nt	Resistance(+4.6%)	2p 163,145
International Resistance Co.				
0.1K+2% RN20R1000G (4 ea)	2.5(10)	1.2(15)ne 8.9(17)nt	Resistance(+16.9%) @ 1.13(15)ne	2p 147,144
1K+1% RN70B1001F (3 ea)	4.1(10)	2.1(15)ne 1.7(18)nt	Resistance(+1.1%)	2p 145,186
100K+2% RN20R1003G (4 ea)	4.0(10)	2.0(15)ne 1.3(18)nt	Resistance(+11.8%) @ 1.88(15)ne	2p 144,149
1 Meg+2% RN20R1004G (4ea)	4.0(10)	2.0(15)ne 1.3(18)nt	Resistance(+3.1%) @ 1.22(15)ne	2p144,150

2.22 **RESISTORS**

2.22.3 CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>Allen-Bradley Co.</u>				
0.1K±10%, 1W Type GB, RC-30(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.9%) @ 2.88(10)ergs/gm-(C)	23p 19,48,61
0.1K ½W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-12%)	15p 26
0.1K, MIL-R-11B RC32GF101J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-2.7%) @ 4.34(14)ne	2p 25
0.1K RC20 BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-2.9%)	1p 300 689
0.1K±10%, ½W Type EB, RC-20(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+7.5%) @ 3.54(9)ergs/gm-(C)	23p 19,48,63
0.1K±10%, 2W Type HB, RC-30 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.1%) @ 1.95(10)ergs/gm-(C)	23p 19,48,61
1K, MIL-R-11B RC32GF102J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-3.3%) @ 7.06(14)ne	2p 27
1K, RC20BF102J (5 ea)	2.9(10)	1.0(15)ne	Resistance(-5.5%)	1p 308, 689
10K±10%, ½W Type EB, RC-20(12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4%) @ 1.5(10)ergs/gm-(C)	23p 19,48,60
10K±10%, 1W Type GB, RC-30 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-4.9%) @ 1.95(10)ergs/gm-(C)	23p 19,48,60

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Allen-Bradley con't				
22K$\pm$5% RC07 (1 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(+0.14%)	10p 126
34K$\pm$5% RC07 (1 ea)	1(9)	7(15) (E>0.1Mev)	Resistance($\ll$1%)	10p 126
125K RC20BF124J (4 ea)	5.7(10)	2.1(15)ne	Resistance(-7.7%) @ 1.87(15)ne	1p 325, 690
125K RC32GF124J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-6.5%) @ 6.58(14)ne	2p 29
240K, $\frac{1}{2}$W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-12%)	15p 26
1 Meg $\frac{1}{2}$W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-9%)	15p 26
1 Meg RC32GF105J (12 ea)	2.6(10)	1.0(15)ne	Resistance(-6.8%) @ 6.58(14)ne	2p 31
10 Meg, $\frac{1}{2}$W (3 ea)	5.7(10)	2.5(17)ne	Resistance(-10%)	15p 26

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	$\frac{n}{cm^2}$		
International Resistance Co.				
0.1K+10%, 2W Type BTB, RC-41 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+5%) @ 1.95(10)ergs/gm(C)	23p 19,48,50
10K+10%, 2W Type BTB, RC-41 (12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+6.3%) @ 1.95(10)ergs/gm-(C)	23p 19,48,51
10K+10%, 2W BT-13, RC41G1002K (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(+0.75%) @ 2.97(13)nf	22p 3,31
Speer Carbon Co.				
0.1K RC20BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-10.3%)	1p 300,689
1K RC20BF102J (3 ea)	2.9(10)	1.0(15)ne	Resistance(-4.8%) @ 9.45(15)ne	1p 308, 689
125K RC20BF124J (4 ea)	5.7(10)	2.1(15)ne	Resistance(-5.9%) @ 1.9(15)ne	1p 325,690
1 Meg RC20BF105J (4 ea)	2.1(10)	6.6(14)ne	Resistance(-20.5%)	1p 317, 690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistor, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Stackpole Carbon Co.				
0.1K RC20BF101J (4 ea)	5.1(10)	3.1(15)ne	Resistance(-3.3%)	1p 300,689
1K RC20BF102J (4 ea)	2.9(10)	1.0(15)ne	Resistance(-6.7%)	1p 308,689
125K RC20BF124J (4 ea)	5.7(10)	2.0(15)ne	Resistance(-15.8%) @ 1.9(15)ne	1p 325,690
1 Meg RC20BF105J (4 ea)	2.1(10)	6.6(14)ne	Resistance(-13.1%) @ 6.2(14)ne	1p 317,690

2.22 RESISTORS

2.22.4 CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Carbon Film	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Aerovox Corp.				
0.1K±2% RN20X1000G	4.0(10)	2.0(15)ne	Resistance(+4.3%) @ 1.4(15)ne	2p152,144
0.1K±2% RN25X1000F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1.7%) @ 9.9(14)ne	2p167,144
0.1K±2% RN25X1000G (4 ea)	2.5(10)	1.2(15)ne	Resistance(+1.6%) @ 1.04(15)ne	2p 177,144
1K±2% RN20X1001G (4 ea)	2.5(10)	1.2(15)ne	Resistance(-1.7%) @ 2.54(14)ne	2p 153,144
1K±2% RN25X1001G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.5%) @ 2.49(13)ne	2p 179,144
100K±2% RN20X1003G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-1.9%) @ 1.75(14)ne	2p 156,144
100K±2% RN25X1003G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.5%) @ 1.34(13)ne	2p 181,145
250K±1% RN25X2503F (2 ea)	4.5(10)	2.3(15)ne	Resistance(-0.8%) @ 1.76(15)ne	2p 175,144
1 Meg±2% RN25X1004G (3 ea)	3.8(10)	2(15)ne	Resistance(-5%) @ 1.42(15)ne	2p 182,145
1 Meg±2% RN20X1004G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-2%) @ 1.67(14)ne	2p 159,144
1 Meg±2% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-2.7%) @ 2.63(13)ne	2p 172,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm²		
Resistors, Carbon Film				
Daven Co., The				
0.1K+1% RN25X1000F (4 ea)	2.5(10)	1.2(15)ne	Resistance(+2.6%)	2p 168,144
International Resistance Co.				
0.1K+1%, 2W Type DCH, RN-30(12ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+3%) @ 1(10)ergs/gm-(C)	23p 19,48,55
0.1K+2% RN20X1000G (4 ea)	2.5(10)	1.2(15)ne	Resistance(-1.6%) @ 2.67(14)ne	2p176,144
0.1K+2% RN20X1000G (4 ea)	4.0(10)	2.0(15)ne	Resistance(-1.4%) @ 2.49(13)ne	2p 151,144
0.1K+1% RN25X1000F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1.1%) @ 8.54(14)ne	2p 165,144
0.1K+1% RN75B1000F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+1.3%) @ 9.6(13)ne	2p 188,144
0.1K, ½W (Molded) (3 ea)	5.67(10)	2.5(17)ne	Resistance(+2.5%)	15p 25, 29
1K+2% RN25X1001G (4 ea)	3.8(10)	2(15)ne	Resistance(-1.7%) @ 1.3(13)ne	2p 178,144
1K+2% RN20X1003G (4 ea)	2.0(10)	8.0(14)ne	Resistance(-1.1%) @ 1.59(14)ne	2p 154,144
1K+2% RN70A1001F (3 ea)	4.1(10)	2.1(15)ne	Resistance(+25.1%)	2p 185,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Resistors, Carbon Film				
I R C con't				
1K+1%, ½W 350V Type HTC (6 ea)	3(10)	1.4(14) (E > 0.5 Mev)	Resistance(+0.2%) @ 5.2(13)nf	4p 42
" (6 ea)	6(9)	2.2(16) (E > 0.5 Mev)	Resistance(-1.8%) @ 1.04(16)nf	40p 40
1K+1%, 1W 500V Type HTF (6 ea)	5.4(10)	1.6(16) (E > 0.5 Mev)	Resistance(-1.8%) @ 1.09(16)nf	4p 41
" (6 ea)	2.6(10)	1.2(14) (E > 0.5 Mev)	Resistance(-0.5%) @ 4.47(12)nf	4p 43
1K RF50K102 (3 ea)	2.9(10)	1.7(15)ne	Resistance Varies from (+5.6%)-max.of (+6.04%) at shutdown	1p 367,690
10K RF50K103 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+6.69%) 1 failed-opened	1p 375,690
10K+1%, 2W DCH, RN30X1002F (12ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-2.1%)	22p 3,31
10K+1%, 2W Type DCH, RN30 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.5%) @ 4.43(9)ergs/gm-(C)	23p 19,48,55
77K+2%, ½W RN20X, DCC Series (3 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-1.3%) @ 7.5(14)nf	10p 126
100K RF40K104K (6 ea)	2.9(10)	1.7(15)ne	Resistance(-4.93%) @ 3.19(14)ne	1p 349,690
100K RF50K104 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+9.93%)	1p 384,690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Carbon Film	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
<u>I R C con't</u>				
100K±2% RN25X1003G (4 ea)	3.9(10)	2(15)ne	Resistance(-1.8%) @ 1.34(13)ne	2p 180,144
240K, ½W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+2.5%)	15p 25,29
250K±1% RN75B2503F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+4.4%) @ 2.19(15)ne	2p 191, 144
250K±1%, ½W, 350V Type HTC (6 ea)	3.8(9)	1.6(16) (E > 0.5 Mev)	Resistance(+4.2%) @ 5.4(13)nf	4p 40
" (6 ea)	3 (10)	1.4(14)nf	Resistance(+1.7%)	4p 42
250K±1%, 1W, 500V Type HTF (6 ea)	6(9)	1.6(16) (E > 0.5 Mev)	Resistance(-2.7%) @ 1.34(16)nf	4p 41
" (6 ea)	3.3(10)	1.9(14) (E > 0.5 Mev)	Resistance(+2.3%) @ 1.07(14)nf	4p 43
250K±1% RN25X2503F (2 ea)	4.2(10)	2.0(15)ne	Resistance(+1.1%) @ 8.6(14)ne	2p 173,144
1 Meg±2% RN25X1004G (4 ea)	3.9(10)	2(15)ne	Resistance(-2.4%) @ 2.26(14)ne	2p 183, 144
1 Meg±1% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(+2.7%) @ 9(14)ne	2p 170, 144
1 Meg±1% RN75B1004F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+2.5%) @ 4.31(14)ne, all opened @ 9.6(14)ne	2p 190,144

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Film	DESIGN ALLOWABLES ergs/gm-(C)	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
I R C con't				
1 Meg, ½W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+7%)	15p 25,29
1 Meg±1%, ½W, 350V Type HTC (6 ea)	7.4(9)	2.2(16) (E > 0.5 Mev)	Resistance(-2.8%) @ 6.8(15)nf	4p 40
" (6 ea)	2.6(10)	1.2(14)nf	Resistance(+3.4%)	4p 42
1 Meg±1%, 1W, 500V Type HTF (6 ea)	5.4(9)	1.6(16) (E >0.5 Mev)	Resistance(-2.2%) @ 3.68(15)nf	4p 41
" (6 ea)	3.3(10)	1.9(14) (E > 0.5 Mev)	Resistance(+2.4%) @ 1.08(14)nf	4p 43

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	n/cm^2		
Resistors, Carbon Film				
Mepco, Inc.				
0.1K+1% RN75B1000F (3 ea)	4.6(10)	2.2(15)ne	Resistance(+2.7%) @ 9.6(14)ne	2p 187,145
0.1K+1%, 5W Type C-25P (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+2.4%) @ 2.52(10)ergs/gm-(C)	23p 19,48,57
10K+1%, 2W C177BN, RN80B1002F (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-0.6%)	22p 3, 33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(-0.5%) @ 3.54(9)ergs/gm-(C)	23p19,48,57
10K+1%, 5W Type C-25P (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(-0.2%)	22p 3, 31
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.8%) @ 8.63(9)ergs/gm-(C)	23p 19,48,57
10K+1%,1/8W(Herm.Seal) LS 8456-090 (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.63%)	10p 129
" (4 ea)		1.3(16) (E>0.1Mev)	Resistance(+1%)	32p 3,Fig.28
15K+1%, 1/8 W, RN60B (Herm. Sealed) (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(+0.13%)	10p 130
" (4 ea)		1.3(16)nf	Resistance(+1%)	32p 3, Fig.28
27K+1% RN65B2702 (4 ea)	2.6(10)	1.4(15)ne	Resistance(-1.59%) @ 3.28(14)ne	2p 184,145

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Carbon Film	ergs / gm-(C)	n / cm²		
Mepco con't				
250K+1% RN75B2503F (3 ea)	4.6(10)	2.2(15)ne	Resistance(-0.8%) @ 1.05(15)ne	2p 191, 145
1 Meg+1% RN75B1004F (3 ea)	4.6(10)	2.2(15)ne	Resistance(-1.9%) @ 1.62(15)ne	2p145,189
Resistance Products Co.				
10Ω RF40 K100 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-1.68%) @ 1.68(15)ne	1p332,690
10Ω RF50 K100 (3 ea)	2.9(10)	1.7(15)ne	Resistance(+3.81%) @ 1.68(15)ne	1p 356,690
0.1K RF50 K101 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-9.63%)	1p 361,690
1K RF50 K102 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-1.1%) @ 1.59(15)ne	1p 369,690
1K RF40 K102 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-4.89%) @ 6.47(13)ne	1p337,690
10K RF40 K103 (6 ea)	2.9(10)	1.7(15)ne	Resistance(-2.27%) @ 6.47(13)ne	1p343,690

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Carbon Film	ergs/gm-(C)	n/cm²		
RPC con't.				
10K RF50K103 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-0.91%) @ 5.18(14)ne, 1 ea opened in-pile	1p377,690
100K RF50 K104 (3 ea)	2.9(10)	1.7(15)ne	Resistance(-1.11%) @ 3.19(14)ne	1p386, 690
Sprague Products Co.				
0.1K+1%, $\frac{1}{4}$W(Filmistor) RN65B, 406E 1000F (1 ea)	6.2(10)	4.2(16) (E>0.1Mev)	Resistance(+26.9%) @ 1.29(15)nf	12p 178
1K (Pyrolytic) RN65B, Type 406E	7.2(9)		Resistance(+0.2%)	43p212-14
1 Meg (Pyrolytic) RN65B, Type 406E	7.2(9)		Resistance(-0.2%)	43p 212-14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Resistors, Carbon Film				
Texas Instruments Inc				
0.1K+1% RN25X100F (2 ea)	2.5(10)	1.2(15)ne	Resistance(+1%) @ 1.61(14)ne	2p166,144
0.931K+1% CD ¼R	7.5(9)	3.7(15) (E > 1Mev)	Resistance(+1.84%) @ 5(14)nf	12p 157
"		1.3(15) (E>2.9Mev)	Resistance<<<1% Rec. for Low Pwr. Nuc. Environments	11p 23,25
250K+1% RN25X2503F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-0.6%) @ 1.23(15)ne	2p 174,144
1 Meg+1% RN25X1004F (2 ea)	4.2(10)	2.0(15)ne	Resistance(-5%) @ 2.63(13)ne	2p 171,144
Western Electric				
0.1K ½W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+0.8%) Not Rec. for Nuc. use	15p 25,28
250K ½W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+13%) 1 failed, not Rec. for Nuc. use	15p 25,28
1 Meg ½W Epoxy Tube (3 ea)	5.6(10)	2.5(17)ne	Resistance(+38%) Not Rec. for Nuc. use	15p 25,28
1 Meg 2W Glass Enclosed (3ea)	5.6(10)	2.5(17)ne	Resistance(+6%) 1 failed @ 2(17)ne	15p 30,31
5 Meg 2W Glass Enclosed (3ea)	5.6(10)	2.5(17)ne	Resistance(+5%) 1 failed @ 9(16)ne	15p 30,31

2.22 RESISTORS

2.22.5 METAL FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Metal Film	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Corning Glass Works				
0.1K±2%, 7W, Pyrex core, RD31P1000G (6ea)	3.0(10)	3.1(13)nf	Resistance(+2.8%) @ 2.69(13)nf	2p 38,36
0.1K±2%, 2W, Solid Glass core RD65P1000G (6 ea)	4.5(10)	2.3(15)ne	Resistance(+8.5%) @ 1.36(15)ne	2p 42, 36
5.65K±2%, ½W, @ 120°C 350V Pyrex core, CGW-S-20 (1 ea)	6.2(10)	4.2(16) (E > 1 Mev)	Resistance(-0.64%) @ 1.65(16)nf	12p 161
"		1.5(16) (E>2.9Mev)	Resistance(-0.64%) @ 5.9(15)nf, Rec. for Low Pwr. Nuc. use	11p 11,25
15K±2%, 2W, Solid Glass core, RD65P1502G	4.5(10)	2.3(15)ne	Resistance(+7%) @ 1.58(15)ne	2p 43, 36
30K±2%, 2W, Solid Glass core, RD65P3002G	4.2(10)	6.1(13)nf	Resistance(+22.99%) @ 5.3(13)nf	2p 44,36
38K±2%, 7W, Pyrex core RD31P3832 (3 ea)	4.2(10)	2.0(15)ne	Resistance(+4.4%) @ 1.48(15)ne	2p 39, 36
" (3 ea)	3.0(10)	2.1(13)nf	Resistance(+2.1%) @ 2.77(13)nf	2p 40, 36
40K±2%, 2W, Solid Glass core, RD65P4003G (6 ea)	3.0(10)	3.1(13)nf	Resistance(+26.4%) @ 2.8(13)nf	2p 45, 36
68K±2%, 7W, Pyrex core RD31P6812G (6 ea)	3(10)	3.1(13)nf	Resistance(+2.9%) @ 2.01(13)nf	2p 41, 36

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Metal Film	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Daystrom, Inc.				
1K+1%, ½W, Vamistor 1001F #9852 (1ea)	6.2(10)	4.2(16) (E > 1Mev)	Resistance(+2.26%) @ 1.29(15)nf	12p 179
International Resistance Co.				
0.1K, ½W Molded (3 ea)	5.6(10)	2.5(17)ne	Resistance(+1.5%) @ 9(16)ne	15p 26, 23
2.5K+1% (glass) XLT Series (4 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.28%)	10p 126
2.87K+1%, 0.1W RN55, EM Series (4ea)	1(9)	7(15) (E>0.1Mev)	Resistance(+0.28%) @ 6(12)nf	10p 126
9.75K+1%, 1/8W Herm. Sealed-Glass Type XLT (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance(0.0%)	10p 128
10K+1%, ¼W CEB Series (4 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.28%) @ 6(12)nf	10p 126
10K+1%, 1/8W, MEA Series, RN60C1002F (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance(+0.02%) @ 1.5(13)nf	10p 127
67K+1% RN60C (2 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(0.0%)	10p 126
81K+1% RN60C (2 ea)	1(9)	7(15) (E>0.1Mev)	Resistance(-0.12%) @ 6(12)nf	10p 126

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Metal Film	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
I R C con't				
240K, $\frac{1}{2}$W Molded (3 ea)	5.7(10)	2.5(17)ne	Resistance(+0.9%)	15p 26, 23
1 Meg $\frac{1}{2}$W Molded (3 ea)	5.7(10)	2.5(17)ne	Resistance(+1.3%) @ 7(16)ne	15p 23, 26
Key Resistor Corp				
0.1K+1% Type A-66 (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(+27.1%) @ 9.54(13)nf	12p 177
30K+1%, $\frac{1}{2}$W @ 125°C 350V, EM-70, MIL-R-10509-C (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-5.8%)	12p 175
100K+1%, $\frac{1}{2}$W @ 125°C 350V, EM-70, Mil-R-10509-C (1 ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-2.06%) @ 2.67(16)nf	12p 174
100K+1% A-66, Mil-R-10509-C (1ea)	7.2(10)	4.8(16) (E > 1Mev)	Resistance(-1.6%) @ 2.67(16)nf	12p 176

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Metal Film	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Litton Systems, Inc.				
0.26K, Deposited Ni Cr film on $BaTiO_3$ wafer (1 ea)	7.5(10)	4.0(16) (E > 1Mev)	Resistance(+8.86%) @ 1.9(15)nf	12p 167
0.28K, Deposited NiCr film on BaTi O_3 wafer (1 ea)	7.5(10)	4.0(16) (E > 1Mev)	Resistance(+8.66%)	12p 166
Ohmite Manufacturing Co.				
0.1K±1%, ¼W Type 771-2 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+2.1%) @ 1.81(10)ergs/gm-(C)	23p 19, 48
10K±1%, ¼W Type 771-2 (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.4%) @ 4.87(9) ergs/gm-(C)	23p 19, 48
Pyrofilm Resistor Co., Inc.				
125K±1% Type PT-60 (1 ea)	7.5(10)	4.0(16) (E > 1Mev)	Resistance(+2.65%) @ 1.19(15)nf	12p 168
2 15K±1% Type PT-60 (1 ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-6.42%) @ 1.3(16)nf	12p 169

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Metal Film	ergs/gm-(C)	n/cm^2		
Sprague Products Co.				
1K RN65C, Type 419E	7.1(9)		Resistance(+0.1%)	43p 214
750K RN65C, Type 419E	7.1(9)		Resistance(-0.05%)	43p 214
Varo Manufacturing Co., Inc.				
0.65K, Experimental Microcircuit, NiCr Film, No. 235	1.9(10)	1.5(15) (E>2.9Mev)	Resistance(0.0%) Rec. for use in Nuc. Environment	12p 153 11p 25
Weston Instruments Div of Daystrom, Inc.				
0.25K ½W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Resistance(+200%) 2 failed,(not Rec. for Nuc. use)	15p 25,27
10K+1%, ½W, 9800Series RN 60C1002F (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance<<1%	10p 127
240K, ½W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Opened after a dose 2.7(16)ne, (not Rec. for Nuc. use)	15p 25, 27
1 Meg, ½W Vamistor Type (3 ea)	5.7(10)	2.5(17)ne	Opened after dose of 2.7(16)ne (Not Rec. for Nuc. use)	"

2.22 RESISTORS

2.22.6 TEMPERATURE SENSITIVE

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Temp. Sensitive	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Texas Instruments, Inc.				
0.1K$\pm$10% @ 25°C Sensistor, Silicon Temp. Sens. P-100	7.6(9)	3.8(15) (E>1Mev)	Resistance(+2280%)	12p 158
0.1K$\pm$10% @ 25°C Type TO12 Silicon, Sensistor, TC-1/8	7.6(9)	3.8(15) (E>1Mev)	Resistance(+6290%)	12p 159 11p 23

2.22 RESISTORS

2.22.7 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Cinema Engineering				
1K+1% @ 25°C, ½W @ 300V, Mil-R-93, Mil-R-9444, CE 276E (1ea)	6.3(10)	4.3(10) (E > 1Mev)	Resistance(+2.34%) @ 1.29(15)nf	12p 171
1K+1% @ 25°C, 1W @ 600V, CE 278E (1 ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(+1.74%) @ 2.4(16)nf	12p 173
100K+1% @ 25°C, 1W @ 600V, CE 278E (1ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-1.74%) @ 3.35(16)nf	12p 172
100K+1% @ 25°C, ½W @ 300V, CE 276E (1ea)	6.3(10)	4.3(16) (E > 1Mev)	Resistance(-2.29%) @ 2.4(16)nf	12p 170
Dale Products, Inc.				
1K+1%, 1W, Precision RS-1A (4 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.9%) @ 6(15)nf	10p 129
1K+1%, 1W, Precision Power, ARS-2 (2 ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(<< 1%)	10p 129

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Wire wound	ergs / gm-(C)	n / cm²		
Daven Co., The				
0.1K+0.5% Mil-R-9444(USAF) AFRT 19E100ROD (3ea)	4.5(10)	5.4(13)nf	Resistance(+0.4%) @ 1(12)nf	2p 129,117
0.1K+0.5% Mil-R-9444(USAF) AFRT19J100ROD (3ea)	4.5(10)	5.4(13)nf	Resistance(-0.7%) @ 2.3(13)nf Blistered	2p 117, 135
10K+1% AFRT Series (4ea)	2(9)	1.2(16) (E>0.1Mev)	Resistance(-0.07%) @ 6(15)nf	10p 129 32p 3, Fig.28
360K+0.5% Mil-R-9444(USAF) AFRT 19J36002D (3 ea)	4.2(10)	6.1(13)nf	Resistance(-0.3%) @ 5.2(12)nf	2p 136,117
360K+0.5% Mil-R-9444(USAF) AFRT 19E 36002D (3ea)	4.5(10)	6.4(13)nf	Resistance(-0.3%) @ 3.1(13)nf	2p 131,117
1 Meg+0.5% Mil-R-9444 (USAF) AFRT 19E 10003D (3ea)	3.4(10)	3.6(13)nf	Resistance(-2.2%) @ 1.3 (13)nf	2p 133,117
1 Meg+ 0.5% Mil-R-9444 (USAF) AFRT 19J 10003D (3ea)	2.5(10)	3.6(13)nf	Resistance(+3.5%) @ 7.4(11)nf	2p 139,117

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Wire wound	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
International Resistance Co.				
20Ω RW33G20RO (4 ea)	3(10)	2.2(15)ne	Resistance(+9.41%) @ 1.9(14)nf	1p 410, 691
20Ω+5%,1W Mil-R-26C RW31G20RO (4 ea)	2.6(10)	7.4(14)ne	Resistance(+12.5%) @ 4.1(13)ne	2p 53,49
0.1K RB17AE100ROF (4 ea)	3.1(10)	1.2(15)ne	Resistance(+0.49%) @ 9.6(13)ne, 1 ea. operated intermittent	1p 271, 689
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+0.3%) @ 8.8(14)ne	1p 394,691
0.2K+5%, 18W Mil-R-26C RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1.1%) @ 1.54(15)ne	2p 74, 49
0.2K+5%, 38W Mil-R-26C RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance(-0.2%) @ 1.26(15)ne	2p 94, 50
0.314K+0.05% Type 208A	7.5(9)	3.7(15) (E > 1Mev)	Resistance(-0.06%) @ 2.63(13)nf, Rec. for Low Pwr. Nuc. environment	12p 160 11p 25, 23
1K RB 17AE10000F(4 ea)	1.8(10)	6.5(14)ne	Resistance(+0.19%) @ 3.5(14)ne, 1 opened in-pile	1p 280, 689
1K+1%, 3W @ 25°C Mil-R-26C P/N AS2 (1 ea)	6.3(10)	[illegible](16) (E > 1Mev)	Resistance(+7.3%) @ 8.58(13)nf	12p 164

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Wire wound	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>I R C con't</u>				
2K+5%, 38W Mil-R-26C RW35G202 (4 ea)	3.3(10)	1.5(15)ne	Resistance(-0.2%) @ 1.1(13)ne	2p 100,50
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance(+1%) @ 1.24(15)ne	1p 417, 691
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+0.65%) @ 5.9(14)ne	1p 403, 691
10K+1%, 2W WW-2-J, RB16AE1002F (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(0.0%)	22p 3,33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev	Resistance(+0.3%) @ 1.35(10)ergs/gm-(C)	23p 19,48,59
10K+5%, 2W RW32G1002, Type 2C (12 ea)	1.6(9)	7.5(13) (E>2.9Mev)	Resistance(0.0 %)	22p 3, 33
" (12 ea)	6.2(10)	1.4(16) (E>2.9Mev)	Resistance(+0.6%) @ 2.3(10)ergs/gm-(C)	23p 19,48,59
20K+5%, 10W, Mil-R-26C, RW31G203 (4ea)	3.4(10)	1.9(15)ne	Resistance(0.0%)	2p 58, 49
20K+5%, 38W Mil-R-26C RW35G203 (4 ea)	3.8(10)	2.4(15)ne	Resistance(+0.7%) @ 2(15)ne	2p 49, 102
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance(-2.5%) @ 1.8(14)ne	1p 424, 691
100K RB17AE10002F (4 ea)	2.9(10)	9.6(14)ne	Resistance(-0.99%) @ 9.6(13)ne	1p 291, 689

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Kelvin Electric Co.				
10K±1%, 0.1W EP Series (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance<< 1%	10p 127, 4 36 Fig. 32
11K±1%, ¼W EP Series (4 ea)	1(9)	6.8(15) (E>0.1Mev)	Resistance(-5.17%) @ 1.5(13)nf	10p 127, 4
Mepco, Inc.				
0.1K RB17AE100R0F (4 ea)	3.1(10)	1.2(15)ne	Resistance(+3.94%) @ 8.8(14)ne	1p 271, 689
0.1K±½%, Mil-R-9444 AFRT14E100R0D (6 ea)	3.9(10)	5.7(13)ne	Resistance(+0.62%) @ 1.5(13)ne	2p 119, 117
0.1K±½%, Mil-R-9444 AFRT14J100R0D (6 ea)	3.9(10)	5.7(13)ne	Resistance(+0.6%) @ 3.8(13)ne, Blistered	2p 122, 117
0.1K±½%, Mil-R-9444 AFRT14K100R0D (3 ea)	4.5(10)	6.4(13)ne	Resistance(+0.3%) @ 1(13)ne, Blistered	2p 117, 125
0.1K±½%, Mil-R-9444 AFRT19E100R0D (3 ea)	4.5(10)	6.4(13)ne	Resistance(+0.4%) @ 1(13)ne, Blistered	2p117, 128
0.1K±½%, Mil-R-9444 AFRT19J100R0D (3 ea)	4.5(10)	6.4(13)ne	Resistance(+0.5%) @ 2.26(13)ne, Blistered	2p 117, 134
1K RB17AE1000F (4 ea)	1.8(10)	6.5(14)ne	Resistance(+0.79%) @ 3.7(14)ne	1p 280, 689
100K RB17AE10002F (4 ea)	2.5(10)	9.6(14)ne	Resistance(-0.89%) @ 4.1(14)ne	1p 291, 689

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Mepco con't				
360K±½%, Mil-R-9444 AFRT14E36002D (6 ea)	3.9(10)	5.7(13)ne	Resistance(+0.9%) @ 4.4(12)ne, Blistered	2p 120,117
360K±½%, Mil-R-9444 AFRT14J36002D (6 ea)	4.6(10)	6.6(13)ne	Resistance(-0.4%) @ 1.2(13)ne, one opened	2p 117, 123
360K±½%, Mil-R-9444 AFRT14K 36002D (6ea)	4.5(10)	6.4(13)ne	Resistance(-1.1%) @ 2.26(13)ne	2p 117, 126
360K±½%, Mil-R-9444 AFRT19E36002D (3 ea)	4.5(10)	6.4(13)ne	Resistance(-0.3%) @ 3(13)ne	2p 117, 130
360K±½%, Mil-R-9444 AFRT19J36002D (3 ea)	4.2(10)	6.1(13)ne	Resistance(-0.4%) @ 5.2(12)ne	2p 117,137
1 Meg±½%, Mil-R-9444 AFRT14E10003D (5 ea)	3.9(10)	5.7(13)ne	Resistance(+3.2%) @ 4.7(13)ne	2p 117, 121
1 Meg±½%, Mil-R-9444 AFRT14J10003D (6 ea)	4.5(10)	6.4(13)ne	Resistance(-1.5%) @ 3.1(13)ne	2p 117, 124
1 Meg±½%, Mil-R-9444 AFRT14K10003D (6 ea)	4.6(10)	6.6(13)ne	Resistance(-3.6%) @ 3(13)ne, 1 opened in-pile	2p 117, 127
1 Meg±½%, Mil-R-9444 AFRT19E10003D (3 ea)	3.4(10)	3.6(13)ne	Resistance(-2%) @ 1.3(13)ne	2p 117, 132
1 Meg±½%, Mil-R-9444 AFRT19J10003D (3 ea)	2.5(10)	3.6(13)ne	Resistance(+3.5%) @ 1.1(12)ne	2p 117, 138

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Ohmite Manufacturing Co.				
20Ω RW33G20R0 (4 ea)	3(10)	2.3(15)ne	Resistance(+15.06%) @ 1.27(15)ne	1p 470, 691
20Ω+5%, 38W RW35G200 (3 ea)	3.7(10)	2.3(15)ne	Resistance(-3.4%) @ 1.7(15)ne	2p 89, 49
20Ω+5%, Mil-R-26C RW31G20R0 (4 ea)	2.6(10)	7.4(14)ne	Resistance(+6.9%) @ 4.1(13)ne	2p 54, 49
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+2.34%) @ 5.4(14)ne, 1 opened in-pile	1p 394, 691
0.2K+5%, 18W Mil-R-26C, RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+4.4%) @ 1.54(15)ne	2p 75, 49
0.2K+5%, 26W, Mil-R-26C, RW33V201 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1.2%) @ 1.3(15)ne	2p 82, 49
0.2K+5%, 38W Mil-R-26C, RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance(+1.2%) @ 1.57(15)ne	2p 50, 92
0.2K+5%, 14W Mil-R-26C, RW31V201 (3 ea)	4.4(10)	2.3(15)ne	Resistance(+2.9%) @ 1.92(15)ne	2p 49, 63
0.2K+5%, 55W Mil-R-26C, RW35V201 (3 ea)	3.5(10)	1.4 (15)ne	Resistance(+4.1%) @ 1.3(15)ne	2p 50,106
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance(+1.5%)	1p 417, 691
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance(+1.75%) @ 5.4(14)ne, 2 opened in-pile	1p 403, 691

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Resistors, Wire wound				
Ohmite con't				
2K+5%, 14W Mil-R-26C, RW31V202 (4 ea)	3.5(10)	1.8(15)ne	Resistance(+1%) @ 1.3(15)ne	2p 49, 68
2K+5%, 26W Mil-R-26C, RW33V202 (4 ea)	4.1(10)	2.4(15)ne	Resistance(+1 %) @ 1.53(15)ne	2p 49, 85
2K+5%, 38W Mil-R-26C, RW35G202 (4 ea)	3.3(10)	1.5(15)ne	Resistance(+1.15%) @ 8.9(14)ne	2p 96, 50
2K+5%, 55W Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance(+4.1%) @ 9.6(14)ne	2p 110, 49
6K+1%, 1W Size A Mil-R-26C, Mil-R-10509-C, Type 88A (1 ea)	6.3(10)	4.3(16) (E> 1Mev)	Resistance(-0.78%) Recommended for low Pwr. Nuc. Environment	12p 162 11p 25
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance(+0.9%)	1p 424, 691
20K+5%, 55W, Mil-R-26C, RW35V203 (4 ea)	3.8(10)	2.4(15)ne	Resistance(+3.8%) @ 1(15)ne	2p 112, 50
Resistors, Inc.				
2K+5%, 14W Mil-R-26C, RW31V202 (4 ea)	3.2(10)	1.6(15)ne	Resistance(-1%) @1.1(14)ne	2p 70, 49

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sprague Products Co.				
20Ω ±5%, 14 W, Mil-R-26C, RW31Y20RO (4 ea)	4.8(10)	3.1(15)ne	Resistance (+0.3%) @ 2.4(14)ne	2 p. 49, 61
20Ω ±5%, 26W, Mil-R-26 C, RW 33V20RO (4 ea)	3.1(10)	1.9(15)ne	Resistance (-2.8%) @ 8.6(14)ne	2 p. 49, 79
20Ω ±5%, 55W, Mil-R-26C, RW35V20RO (4 ea)	4(10)	3.1(15)ne	Resistance (+3.9%) @ 7.2(14)ne	2 p. 50, 105
0.1K RB17AE100ROF (4 ea)	3.1(10)	1.2 (15) ne	Resistance (+3.31%) @ 9.3(14)ne	1 p. 272, 689
0.2K ±5%, 14W, Mil-R-26C, RW31V201 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+0.25%) @ 1.5(14)ne	2 p. 49, 64
1K RB17AE10000F (4 ea)	1.8(10)	6.5(14)ne	Resistance (+1.58%) @ 5.5(14)ne	1 p. 280, 689
2K ±5%, Mil-R-26C Koolohm, 10 NIT (1 ea)	6.3(10)	4.3(16) (E > 1 Mev)	Resistance (+4.1%) @ 8.6(13)nf	12 p. 163 11 p. 25
2K ±5%, 14W, Mil-R-26C, RW31V202 (4 ea)	3.5(10)	1.8(15)ne	Resistance (-0.7%) @ 2.8(14)ne	2 p. 69, 49
2K ±5%, 55W, Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance (+0.3%)	2 p. 49, 168
20K ±5%, 10W, Mil-R-26C, RW31G203 (4 ea)	3.4(10)	1.8(15)ne	Resistance (+0.1%) @ 8.2(14)ne	2 p. 49, 56
20K ±5%, 14W, Mil-R-26C, RW31V203 (3 ea)	4.4(10)	2.3(15)ne	Resistance (-2.3%) @ 4.6(11)ne	2 p. 72, 49
20K ±5%, 26W, Mil-R-26C, RW33V203 (4 ea)	3.1(10)	1.9(15)ne	Resistance (+0.2%) @ 8.3(14)ne	2 p. 88, 49
100K RB17AE10002F (4 ea)	2.5(10)	9.6(14)ne	Resistance(-0.99%) @ 1.46(14)ne	1 p. 291, 689
2K ±5%, 26W, Mil-R-26C, RW33V202 (4ea)	4.1(10)	2.4(15)ne	Resistance (+0.4%) @ 3(14)ne	2 p. 49, 84

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Truohm Products Div. Model Eng. and Manuf. Co.				
20 Ω RW33G20RO (4 ea)	3(10)	2.3(15)ne	Resistance(-4.92%) @ 1.7(14)ne	1 p. 410, 691
20 Ω +5%, 10W, Mil-R-26C, RW31G20RO (4 ea)	2.6(10)	7.4(14)ne	Resistance (-1%) @ 1.04(13)ne	2 p. 55, 49
20 Ω +5%, 14W, Mil-R-26C, RW31V20RO (4 ea)	4.8(10)	3.1(15)ne	Resistance (+0.3%) @ 1.25(15)ne	2 p. 60, 49
20 Ω +5%, 26W, Mil-R-26C, RW33V20RO	3.1(10)	1.9(15)ne	Resistance (+8.7%) @ 1.3(15)ne	2 p. 49, 78
20 Ω +5%, 38W, Mil-R-26C, RW35G200 (4 ea)	3.7(10)	2.2(15)ne	Resistance (-0.5%) @ 2(14)ne	2 p. 90, 50
20 Ω +5%, 55W, Mil-R-26C, RW35V20RO (4 ea)	4(10)	3.1(15)ne	Resistance (+5.3%) immediately	2 p. 104, 50
0.2K RW31G201 (4 ea)	2.4(10)	9.3(14)ne	Resistance (+1.66%) @ 5.4(14)ne	1 p. 394, 691
0.2K +5%, 14W, Mil-R-26C, RW31V201 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+2.2%) @ 1.9(15)ne	2 p. 49, 66
0.2K +5%, 18W, Mil-R-26C, RW33G201 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+4.3%) @ 1.5(15)ne	2 p. 49, 76
0.2K +5%, 26W, Mil-R-26C, RW33V201 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+1.3%) @ 1.3(15)ne	2 p. 49, 80
0.2K +5%, 38W, Mil-R-26C, RW35G201 (4 ea)	4.1(10)	2.6(15)ne	Resistance (+0.4%) @ 1.6(14)ne	2 p. 50, 93
0.2K +5%, 55W, Mil-R-26C, RW35V201 (3 ea)	3.5(10)	1.4(15)ne	Resistance (-1.1%) @ 1.1(15)ne	2 p. 50, 107
2K RW31G202 (4 ea)	2.4(10)	9.3(14)ne	Resistance (+1.73%) @ 5.9(14)ne, 2 shorted in-pile	1 p. 403, 691
2K RW33G202 (4 ea)	3(10)	2.2(15)ne	Resistance (+1.6%) @ 1.45(15)ne	1 p. 417, 691

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Truohm Cont'd				
2K ±5%, 14W, Mil-R-26C, RW31V202 (4 ea)	3.2(10)	1.6(15)ne	Resistance (+1.2%) @ 1.1(15)ne	2 p. 67, 49
2K ±5%, 26W, Mil-R-26C, RW33V202 (4 ea)	4.1(10)	2.4(15)ne	Resistance (+1%) @ 1.5(15)ne	2 p. 83, 49
2K ±5%, 38W, Mil-R-26C, RW35G202 (4 ea)	3.3(10)	1.4(15)ne	Resistance (+1.21)@ 1(15)ne	2 p. 50, 98
2K ±5%, 55W, Mil-R-26C, RW35V202 (2 ea)	3.1(10)	1.9(15)ne	Resistance (+3.6%) @ 9.4(14)ne	2 p. 49, 109
20K RW33G203 (4 ea)	2.9(10)	2.2(15)ne	Resistance (+1.9%)	1 p. 424, 691
20K ±5%, 10W, Mil-R-26C, RW31G203 (4 ea)	3.4(10)	1.9(15)ne	Resistance (+3.7%) @ 1.7(15)ne	2 p. 49, 57
20K ±5%, 14W, Mil-R-26C, RW31V203 (4 ea)	4.4(10)	2.3(15)ne	Resistance (+4%) @ 1.95(15)ne	2p. 71, 49
20K ±5%, 26W, Mil-R-26C, RW33V203 (4 ea)	3.1(10)	1.9(15)ne	Resistance (+4.59%)	2 p. 87, 49
20K ±5%, 55W, Mil-R-26C, RW35V203 (4 ea)	3.8(10)	2.4(15)ne	Resistance (+3.3%) @ 2(15)ne	2 p. 113, 50
Ultronix, Inc.				
1K ±0.1% 102P-AA	3.9(8)		Resistance(-1.52%) @ 4.7(6)ergs/gm-(C)	12p. 147
1K ±0.1% 102P-AA	1.8(10)	1.4(15) (E > 2.9 Mev)	Resistance (0.0%)	12 p. 151

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Wire wound	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Ultronix, Inc. Cont.				
100K $\pm$0.1% 102P-$\overline{M}$B	3.9 (8)		Resistance (0.0%)	12 p. 147
100K $\pm$0.1% 102P-$\overline{M}$B	1.8(10)	1.4(15) (E>2.9 Mev)	Resistance (0.0%)	12 p. 152

2.23 **SEMICONDUCTOR DEVICES**

2.23.1 DIODES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Bell Telephone Labs				
Diff. junction (zinc)(1 ea.)		4.6 (15) (E>0.1 Mev)	Forward Bias (+19.4%) Reverse V (+20.5%)	17 p 135
Magnesium - doped, Tin Alloyed junction (1 ea.)		4.6 (15) (E>0.1 Mev)	Forward Bias (+43.5%) & Reverse V (37.5%) @ 2.2 (15)nf	17 p 145
Bomac Labs				
1N21B, Si Crystal Rectifier (2 ea)	1.1 (10	6.6(14)ne	Backward I (+1100%) @ 4.5 (14)ne, Permanent damage	1 p 462-473
CBS Hytron, Div. of Columbia Broadcasting System				
1N58 Crystal Rectifier (2 ea.)	3.9(10)	2.4(15)ne	Forward I (-85.5%) Backward I (+7115%) Failed in-pile	1 p 476-484

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CD3137, Zener Diode (3 ea.)	1(9)	6.8 (15) (E>0.1 Mev)	Zener V @ 100 µA (-36.3%) @ 5.4 (15) nf, Knees round	10 p 11, 77, 113 36 Fig. 31
CD 3147 Zener Diode (2 ea)	1(9)	6.8(15) (E>0.1 Mev)	Zener V @ 100 µA (-6.4%) @ 2(13) nf, Knees Round	10 p 11, 77, 113 36 Fig. 30
CD 4113, Zener Diode, Temp. Compensated (2 ea)	1(9)	6.8(15) (E>0.1 Mev)	Zener V @ 100 µA (-41%) @ 5.4(15)nf, Knees Round	10 p 11, 77, 113 36 Fig. 29
<u>Fairchild Semi-Conductor Corp.</u>				
FD204 Diode (4 ea)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (+185%)	10 p 10, 75, 110 36 Fig. 27
FA 2083 Diode (4 ea)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (-23.8%) @ 5.4(15) nf	10 p 10, 110 36 Fig. 25

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>General Electric Co.</u>				
C35, Si PNPN Rectifier (2 ea.)	1.7(7)	7(13) (E>0.1 Mev)	I_{TO} (+1900%) good to ~1(14)nf	16 p 121-131
C5B139, Si Controlled Rectifiers (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 1(12)nf	10 p 13, 116
2N490 Silicon Unijuction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 5(11)nf	10 p 14, 80 53 p 1
2N491 Silicon Unijunction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed @ 5(11)nf	10 p 14, 80 53 p 1
1N2939 Tunnel Diode (5 ea.)	7.5(9)	6.4(15) (E>0.1 Mev)	I_p(-9%) @ 1(14)nf I_v(+122%) V_{fp}(-23%)	10 p 19, 136 139
EM13920A (Graded 2N490) Sil. Unijunction (2 ea.)	1(9)	1(16) (E>0.1 Mev)	Failed 5(11)nf	10 p 14, 80
6RS7PH 70THB1, 1575 VAC Single phase, half-wave, 1.6ma, Selenium Rectifier (2 ea.)	2.5(10)	1.6(16) (E>1 Mev)	DC Output (+10%)	30 p 181-182
6RS32LB1ADH1, 28 Vdc 10A, Single phase, full-wave Selenium Rectifier (1 ea.)	2.5(10)	1.6(16) (E>0.1 Mev)	No changes noted	30 p 181-182

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Kemtron Electron Pdts., Inc.				
1N21B Si Crystal Rectifier (1 ea.)	1.1(10)	6.6(14)ne	Backward I (+150%) @ 5(14)ne, Permanent damage	1 p 462-473
Microwave Associates, Inc.				
1N21B Si Crystal Rectifier (1 ea.)	1.1(10)	6.6(14)ne	Backward I (Failed @ 2.2(14)ne	1 p 462-473
MA-159D Si Mixer 1 to 4 KMc (6 ea.)	8.7(10)	2.1(16) (E>1 Mev)	Still Operational at end of test, gradual degradation	30 p 91-106
Motorola, Inc.				
1N943, Si Reference Diode, Temp. Compensated (5 ea.)	9(8)	8(15) (E>0.1 Mev)	Zener V @ 2.5 ma (+37.2%) Rounding of "breaking point" @ 4.7(14)nf, Zener V changes appreciably @ 3(15)nf	10 p 11, 77, 114 53 p 2
Pacific Semiconductors, Inc.				
PD105 Diode (3 ea.)	1.8(10)	7.9(15) (E>1 Mev)	Forward I @ 2V(-94.2%) @ 2.6(15)nf, Reverse I @ 23.5 V (-94%) @ 2.8(15)nf	12 p 124-126
PC115, Alloyed Si, Abrupt Junction type (3 ea.)	1(9)	6.8(15) (E>0.1 Mev)	Forward V drop (+425%)	10 p 110 36 Fig. 2

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Pacific Semiconductors, Inc. (con't)				
PD-400 Diode (1 ea.)	3.9(8)		Forward I @ 1v (-23.5%) @ 2.4(6) ergs/gm -(C), Reverse I (-50%)	12 p 115
PD-400 Diode (1 ea.)	1.9(10)	1.4(15) (E>2.9 Mev)	Forward I @ 1v (-78.6%), Reverse I (+1300%)	12 p 119
PD-400 Diode (3 ea.)	1.8(10)	7.9(15) (E>1 Mev)	Forward I (+7.1%) Reverse I (-96%)	12 p 130-132
RCA				
Experimental GaAs Tunnel Diodes, Ceramic-to-Metal Seals (7 ea.)	2.7(11)	2.4(17) (E>1 Mev)	Excessive Leakage I @ 6.5 (14)nf	30 p 141
Sylvania Electric Products				
1N21B Si Crystal Rectifier (2 ea.)	1.1(10)	6.6(14)ne	Backward I (Failed) @ 2.2(14)ne)	1 p 462-473
1N58 Crystal Rectifier (2 ea.)	3.9(10)	2.4(15)ne	Forward I (one failed) @ 2.3(14)ne, Backward I (one failed) @ 1(15)ne	1 p 476-484
1N263, Ge Crystal Mixer, 12 KMc (max) (6 ea.)	6(10)	1.6(16) (E>1Mev)	Still operational at end of test, degraded Signal	30 p 91-106

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Diodes	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Texas Instruments, Inc.				
TI-2 Silicon Diode (1 ea.)	5.8(9)	2.9(15) (E>1Mev)	Forward I (-8.2%) Reverse I (+~150%)	12 p 123
Transitron Electronic Corp.				
1N690 Diode (3 ea.)	1.8(10)	7.9(15) (E>1Mev)	Forward I (+14.3%) Reverse I (-89.4%)	12 p 127-129
1N919 Si Diode (4 ea.)	6.4(10)	3.4(16) (E>1Mev)	Forward V drop (+22,013%)	12 p 136
SG 1537 Diode (3 ea)	1.8(10)	7.9(15) (E>1Mev)	Forward I (-68.3%) Reverse I (-88.4%)	12 p 133-135
Westinghouse Electric Corp.				
Experimental gallium - phosphide Diodes (2 ea.)		1.1(16) (E> 0.1 Mev)	Reverse V (+391%) Forward V (+69.6%)	17 p 138
Experimental Si-Carbide Rectifiers (1 ea.)	6.3(9)		Reverse V breakdown (-7.2%), Reverse Bias I (-31%)	17 p 127
Experimental Si-Carbide Rectifiers (3 ea.)		3.5(6) (E>0.1 Mev)	Forward V @ 5 ma (+1400%) @ 1.2(16)nf Reverse V beakdown (+2567%)	17 p 133

2.23 SEMICONDUCTOR DEVICES

2.23.2 TEMPERATURE SENSORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Temp. Sensors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Fenwall Electronics, Inc.				
Thermistors Type X-A 10K 100°C (4 ea) X-B 20 Meg 100°C (4 ea.) X-C 100 Meg 100°C (4 ea.)	3.8(9)	7.2(15) (E>2.9 Mev)	Radiation sensitive. All decreased in resistance due to Radiation but no permanent damage	24 p 296-298
Gulton Industries				
45 T G-2 Thermistor (4 ea.)	7.3(9)		Decrease in R≈ (30%)	10 p 17, 91, 145
45 T G-2 Thermistor (4 ea.)	7.5(9)	4(15) (E>0.1 Mev)	Decrease in R≈ (50%)	10 p 17, 91,
Micro-Sensors Corp.				
T 101-1000, 1K Temp. Sensor (4 ea)	7.8(8)	4.4(15) (E>0.1 Mev)	Failed @ 1(13)nf	10 p 21, 145
Texas Instruments Inc.				
TC-1/8-6038 0.22K Temp. Sensing Resistor (2 ea.)	1.5(9)	1(16) (E>0.1 Mev)	Failed @ 5(13)nf, Not Recommended for use in Nuclear Environment	10 p 12, 46, 115 11 p 25

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices, Temp. Sensors	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Miscellaneous Giannini Controls Corp. Model 8643, Photo-Pots	8.5(8)	4.5(15) (E > 1Mev)		10 p 20, 96
(a) Stintered and Powdered (b) Single crystal			V_{out} (+65%) V_{out} (+67%)	

2.24 SOLDER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Solder	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
MIL Ag 1.5 (97.5% Pb, 1.5% Ag, 1% Sn)			Higher tensile strength than available electronic hardware. High and increasing impact strength at low temperatures; N.B. This appears to be the optimum solder for nuclear environments.	67 P.89

2.25 **SWITCHES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Autronics Corp.				
400 cps Transfer Switch Type III, 1360 (1ea)	1(9)	1(16) (E>0.1Mev)	Unit failed at 4(12)nf and 5(5) ergs/gm-(C)	10 p 23
" (1ea)	1(8)	6.8(14) (E>0.1Mev)	Drop-out V (/75%) Pick-up V(/ 47%) Unit Failed	10 p 159, 23
Giannini Controls Corp.				
Acceleration integrating switch. Type 2358 (2 ea)	2(10)	1.5(16) (E>1 Mev)	1 Failed at 1.8(14)nf No effect on other switch	37 p 8
Kinetics Corp.				
Main Power Transfer, Motor Driven, SPDT M362-1, Ser. 0045 (1 ea)	1(9)	5.8 (15) (E>0.1 Mev	Satisfactory Operation throughout test	10 p 23, 158

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>Leach Corp</u>				
400 cps Transfer, Type 9410, Serial 123 (1 ea)	1(9)	1(16) (E>0.1Mev)	Satisfactory Operation up to 8 (13)nf and 1(7)ergs/gm-(C)	10 p 23
<u>Micro Switch Div. Minn-Honeywell Regulator Co.</u>				
Type 1EN1-6	1.5(10)		Satisfactory Performance Teflon Seal-rings deteriorate	33 p 2, 4
Type 1HS1	1.3(10)		No Effects Noted	33 p 2,4
Model 1HT1, Hi Temp	1.1(11)		No effects Noted	71 p 8
Type 1LS1	1.2(10)		No effect on Switch but rubber seals hardened	3 p 2, 3
Type 1SE1-3	1.5(9)		Increase in Operating and release force and pretravel	33 p 2,5
Type 1SM1	1.3(10)		Case material became Brittle-GF Black Phenolic #7345 Resinox	33 p 2,8

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Switches	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n/cm^2		
Micro Switch Con't				
Type 2EPZ-E	1.2(10)		Seal Becomes Brittle and Breaks	33 p 2
Type BA-2R	1.3(10)		Black Phenolic (ES02403) case became Brittle	33 p 2, 7
Type BZ-2R	1.3(10)		Black Phenolic case becomes Brittle	33 p 2, 7
Type V3-1	1.3(10)		GP Red Malamine 1077-RV22 Melma cover became Brittle	33 p 2, 8
Type V3-1301	1.2(10)		Supramica 555 case became Brittle	33 p 2, 8
Transco Products, Inc.				
SPDT RF Switch 28VDC Type 13730-30 (1 ea)	1.5(9)	8(15) (E>0.1Mev)	Negligible Changes Occurred	10 p 24

2.26 TERMINALS, ELECTRICAL

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Terminals, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Alac, Inc.				
Type 530, Small size composition= Glass-fiber-filled diallyl insulation (6 ea)	9.8(10)	3.1(16) (E>0.5Mev)	All Failed	35 p 10.81
Type 533, Medium Size, Same composition as 530 (6 ea)	9.8(10)	3.1 (16) (E>0.5Mev)	3 Failed, Leakage Resistance decreased by factor of 1 (4)	35 p 10.81
Type 535 Large Size Same composition as 530 (6 ea)	9.8(10)	3.1 (16) (E>0.5Mev)	3 Failed, Leakage Resistance decreased by factor of 1 (4)	35 p 10.81

2.27 THERMOCOUPLES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Thermocouple	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Platinum temperature probe, 100Ω at 0°C			Used to measure air temperature. Induced activity precludes damage error analysis. In previous gamma test, error at 3.96 (8) ergs/g-(C) ~ 0.26°c at 0°C.	11 p 21

2.28 TRANSDUCERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Atlantic Research Corp.				
Model No. LD-77 LeadZirconate, piezoelectric, type-Pressure (1 ea)		1(18)nvt	90% loss of output-not suited for high Radiation Fields	58 p 20, 46
Model #LD-80 Lead Zirconate, Piezoelectric pressure type (1ea)		1(17)nvt	Failed, 20-25% Loss of output at 1(16)nt, not suited for high radiation fields	"
Baldwin-Lima-Hamilton Corp.				
Type AB-7 Resistance-Wire Strain Gage (3 ea)	1.9(9)	2.9(13) (E>0.3Mev)	Strain level (-1.8%) at 4(12)nf	41 p 49-55
Type EBDF-7D Resistance-wire Strain gage (3 ea)	5.8(9)	6.1(13) (E>0.3Mev)	Strain Level- Slight drop throughout test, one failure	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>Bourns, Inc.</u>				
Model 2421 0-4000 PSID Pressure type (1ea)	2.1(10)	5.4(15) (E>1Mev)	Output error Max.of 25%, No Permanent damage	9 p 78
<u>Century Electronics and Instruments, Inc.</u>				
Model 750X 0-75 psig, Si. strip Element, Pressure (1ea)	6.1(10)	2.7(16) (E>1Mev)	Gradual shift in calibration	30 p 202-217
<u>Consolidated Electro-dynamics Corp.</u>				
Model 4-102A vibration pickup fluid-damaged (6 ea)	4.7(9)	4.9(13) (E>.3Mev)	Sensitivity (+17%) at 2.5(13)nf Damping factor (-20%)	41p 14-24
Model 4-118 Magnetic damping, Vibration Pickup(3ea)	"	"	Response curve (+5.8%)	"
Model 4-312 Element-unbonded Strain gage (0-75psia) Pressure Pickup(3ea)	2.1(10)	7.7(15) (E>0.3Mev)	Output(+4000%) at 5.2(15)nf	41 p 36

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
CEC con't				
Type 4-316A Unbonded strain-gauge windings Pressure pickup(1ea)	1(11)		Unaffected by gamma radiation	71 p 16
Dynamic Instrument Co.				
Model P3A1M unbonded strain wire (1 ea)		1(18)nvt	No effects noted	58 p 20
Endevco Corp.				
Model #2501-1000 Ceramic element piezoelectric type (1ea)		1(18)nvt	93% loss of output	58 p 20
Erich Brosa				
Model 6014 quartz Piezoelectric (1ea)		1(17)nvt	10% loss of first Peak at 1(16)nvt	58 p 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Fairchild Controls Corp.				
Model 747E Double Angular position, potentiometer type (1ea)	3.1(10)	7.6(15) (E>1Mev)	Failed in-pile due to electrical wire degradation	9 p 78, 82
Giannini Controls Corp.				
Model 45154 0-20 psia, Pressure pickup Potentiometer Actuated (3ea)	3.2(10)	4.5(15) (E>2.9Mev)	Response curve slope at 10 psig (-6%), Internal wiring was brittle	41 p 37-48
Model 46119Y 0-1500 psia, Potentiometer type, Pressure	2.3(10)	6.7(15) (E>1Mev)	-1.8% Max deviation	9 p 73, 102
Model 46155-H-D 0-4000 Psid Pressure Responsive Bourdon tube and Potentiometer (1ea)	2.4(10)	5.1(15) (E>1Mev)	Response Degraded 8% at 1.8(15)nf and 8.5(9)ergs/gm-(C) DC 510 silicone fluid Failure	9 p 73

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Giannini Con't				
Model 451218 0-30 Psig NI-Span C Element Potentiometer, Pressure type (lea)	2.9(10)	7.2(15) (E>1Mev)	Output (<≠ 1%) up to 3.3(15)nf, Failure due to unknown origin	9 p 69, 101
Model 461265J 1000 psia Potentiometer output	6.4(10)	2.7(16) (E>1Mev)	Satisfactory Performance, No Malfunctions	30 p 202-217
Kistler Instrument Corp. (SLM)				
Model #PZ-14, Quartz Element Piezoelectric type (lea)		1(18)nvt	No effects Noted	58 p 20
Model 701 Quartz Element Pressure pickup (lea)	1(11)		Very sensitive to Radiation, Not Rec. for use in Radiation Field	71 p 16

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Markite Corp.				
Model 3108 Double angular Position, pot. type (1ea)	3.1(10)	7.6(15) (E>1 Mev)	Failure due to degradation of Electrical wire Insulation	9 p 78
Norwood Controls Div. Of Detroit Controls				
Model #EPK-1000 Strain Wire Type bonded - 2-arms of bridge element (1ea)		1(17)nvt	10% Loss of Output at 1(16)nvt	58 p 20
Omega Instrument Co.				
Model #21-10 Variable Capacitance Type (1 ea)		1(17)nvt	50% loss of output	58 p 20
Statham Instruments Inc.				
Model PA-217a-1M-350 unbonded 4-armbridge Element, strain wire Type (1 ea)		1(18)nvt	Failed Electrically	58 p 20
Model PA-217ca-1M-350 unbonded 4-armbridge element, strain wire Type (1 ea)		1(17)nvt	No effects noted	58 p 20

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transducers	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Trans-Sonics, Inc.				
Model 1301D Bulb Resistance Thermometer, Platinum winding pickup (2ea)	1(11)	3.2(13) (E>0.3Mev)	Response (-22%) at 4(12)nf	41 p 25 - 30
Model 2115 0-150 psia Pressure Type (1ea)	2.3(10)	6.7(15) (E>1Mev)	Max. of 6.5% Output Error, Operated Satisfactorily	9 p 78, 81
Ultradyne Engineering Lab, Inc.				
Model S-3 0-50 psia, inductive sensing element, pressure pickup(3ea)	2.1(10)	7.8(15) (E>0.3Mev)	Output at 50 Psia (-87.7%), permanent radiation damage incurred	41 p 36, 38, 43-46
Wiancko Engineering Co.				
Model PX94 0-1000psig Variable-reluctance, pressure type (1ea)	6.3(10)	2.6(16) (E>1Mev)	(0.5%) zero shift & (-2.8%) slope shift at 1.6(16)nf	30 p 201-217

2.29 **TRANSFORMERS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Aladdin Electronics				
Type 02-164 1:10 step-up Epoxy encapsulated Al cased, pulse type (4ea)		4.5(16) (E>0.5Mev)	Wave-forms showed slight degradation, Output V (decrease) Rec. for use in Nuc. Environment	35 p 10.35
Arnold Magnetics Corp.				
Part #533-769 Encapsulated, 6.3 V 400 cycle, filament XFmr. at 3.5A, 115V single phase Primary Pwr. XFmr.		3.2(16) (E>0.5Mev)	No Physical Damage Resistance & secondary V-No degradation	35 p 10.130
Part #77-777 hermetically sealed, 500v, 400 cycle Secondary at 100ma, 115V, single phase secondary, Pwr. XFmr.		3.2(16) (E>0.5Mev)	"	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES ergs / gm-(C)	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Electron Mfg. Co.				
Encapsulated Type (various elements used in construction make-up)	9.5(9)	3.2(16)ne	No Physical or Electrical damage.	3 p 12-25
Hermetically sealed type (Various elements used in construction make-up)	1.1(10)	3.2(16)ne	Some samples ruptured (wax potted and some asphalt potted is cause of rupture and failure), All electrical parameters remained unchanged.	3 p 12-25
Engineered Magnetics Div. of Gulton Industries, Inc.				
Type #14902 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(Δ1%)	10 p 23, 161
Type #14898 (2 ea)	1(9)	6.3(15) (E>0.1Mev)	Magnetizing I(Δ37.7%) at 150V for #1, #2 (Δ1500%) at 2(14)nf	10 p 23, 160

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm^2		
Microtran Co., Inc.				
Type VM5-H(Transistor) Hermetically Sld. Interstage, 5mw, (3ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R(+5.3%) Self Inductance(-18%) IR-Pri. To sec. decreased factor~100	4 p 81-97
Type VM 8-H, Hermetically sealed Audio output, 15mw (Transistor)(3ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R(-16%) Self Inductance (+25%),IR-Pri. to Sec. decreased factor~100	4 p 81-97
Raytheon Mfg. Co.				
HTL-T-434-A Power Xfmr, silicone rubber encapsulate (4 ea)	~5(9)	~1(16) (E>0.5Mev)	IR-Pri. to sec. at 600v-decreased factor ~100, silicone cracked and flaked off.	4 p 60-80
Schaevitz Engineering Co.				
Model 200SS-L Linear variable diff. Transformer, (9 with cores cycled, 3 with cores locked in null position) (12ea)		5.1(16) (E>0.3Mev)	Insulation on wire disintegrated, Inconclusive due to leads shorting	41 p 29-22

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Stancor (Chicago Standard Transformer Corp.)				
S-16147 Metal case, potted with silicasand Power Xfmr. (4 ea)	~5(9)	~1(16) (E>0.5Mev)	IR-Pri. to sec. at 600v-decreased factor ~100, one drew excessive primary I in-pile	4 p 60-80
S-16148 same as S-16147 without metal case (4ea)	"	"	IR-Pri. to sec. at 600V-decreased factor ~100	"
UM-110, Audio Interstage, 1mw Open frame (3ea)	2.5(10)	1.3(14) (E>0.5Mev)	Primary R(-15%) Self induction(+36%) Primary to core short on all units	4P 81 - 97
UM-112, Audio Hi-Z Input, 1mw, Open frame (3ea)	3.9(10)	2.3(14) (E>0.5Mev)	Primary R(-3.5%) Self Inductance (+420%) IR-Pri. to core decreased factor ~100	"
UM-114 Audio Output, 1mw, open Frame (3 ea)	"	"	Primary R (failed) Self Induction(-28%) Ir-Primary to core decreased factor ~10	"
Sylvania Electric Products, Inc.				
Type 23130, Audio Z =9K +- 10% (11ea)		3.9(16) (E>0.5Mev)	Pri. and Sec. R (small) Inductance (+20%) constitutes failure	35 p 10.131-

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Telex, Inc.				
Telex, Inc.				
Type 11135, Audio Interstage, 1 mw, Open Frame (3 ea)	2.5(10)	1.3(14) (E>0.5Mev)	Primary R (Failed) Self Inductance(-15%) IR-Pri. to core decreased factor ~100	4 p 81-97
Type 11137, Audio Output, 1 mw, Open Frame (3ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R (+5.8%) Self Inductance (-9.5%), IR-Pri. to sec. decreased factor ~10	"
Type 8929, Audio Output, 3mw, open Frame (3ea)	5.1(9)	1.8(16) (E>0.5Mev)	Primary R(+5.9%) Self Inductance(-11%) IR-Pri. to core decreased factor ~10	"
United Transformer Corp.				
AR-378, Audio Hermetically sealed, Epoxy resin fill, (4ea)	7.6(12)	3.5(16) (E>0.5Mev)	Cases ruptured due to outgassing	35 p 10.133, 3.27
Dot-1-Audio Interstage, 50 mw, Hermetically sealed (3 ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R(+32%) Self Induction(+21%) IR-Pri. to sec. decreases factor ~100	4 p 81-97
" (3 ea)	2.6(10)	1.3(14) (E>0.5Mev)	Primary R (+13%) Self induction (+23%), IR-Pri. to core decreases factor ~ 100	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transformers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
UTC con't				
Dot - 5, audio Output, 100 mw, Hermetically sealed (3 ea)	6.1(9)	2.2(16) (E>0.5Mev)	Primary R(-2%) Self Inductance (+8%) IR-Pri. to Sec. decreases factor~100	4 p 81-97
Dot-7- Audio Input, 25 mw, Hermetically Sealed (3 ea)	4.6(9)	1.4(16) (E>0.5Mev)	Primary R (+8.9%) Self Inductance (+15%) IR-Pri. to Sec decreases factor ~10^3	"
" (3 ea)	4.1(10)	2.5(14) (E>0.5Mev)	Primary R (+13.5%) Self Induction(-15.6%) IR-Pri. to Core decreases factor~100	"

2.30 TRANSISTORS

2.30.1 GERMANIUM

2.30.1.1 NPN

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Texas Instruments, Inc.				
2N797 Mesa (1 ea)	3.9(8)		β/β_o(dc) (-23.3%) @ 7.1(17)ergs/gm-(C)	12 p73
2N797, Mesa (1 ea)	4(9)	2.7(14) (E>2.9Mev)	β/β_o(dc) (+9.14%) @ 7.6(13)nf	12 p79
2N797, Mesa (3 ea)	9.5(9)	4.2(15) (E>2.9Mev)	β/β_o(dc) (-92%)	21 p99-101
2N797 Epitaxial	5.9(9)	2.9(15) (E>1 Mev)	β/β_o(dc) (-82.8%) @ 2.8(15)nf	12 p102

2.30 **TRANSISTORS**

2.30.1 **GERMANIUM**

2.30.1.2 **PNP**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Bendix Corporation				
EM73327-U, diff. alloy (Graded 2N1653) F_T 600Kc(min) (3 ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 3(13)nf	10 p59
Motorola Semiconductor Products, Inc.				
2N700 Mesa (1 ea)	4(8)		β/β_o(dc) (+9.47%)	12 p74
" (1 ea)	5.9(8)	1.5(13) (E>2.9Mev)	β/β_o(dc)(+1900%) @ 1.1(13)nf	12 p80
" (2 ea)	1.1(10)	5(15) (E>1 Mev)	β/β_o(dc) (-36.7%)	12 p108-109
2N828, Epitaxial Mesa (3 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) (-96%) @ 2.6(15)nf	12 p110-112
2N1561 Mesa (1 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) (-55%) @ 1.2(15)nf	12 p106
Philco Corporation				
2N769 (1 ea)	4(8)		β/β_o(dc) (+100%) @ 6(6) ergs/gm-(C)	12 p75
" (1 ea)	1.4(9)	7.6(13) (E>2.9Mev)	β/β_o(dc) (+764%)	12 p81
L-5446 MADT (5 ea)		1(14)nvt	No Serious Damage	75 p47

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Germanium (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Texas Instruments, Inc.				
2N1141 Mesa (1 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) (-97%) @ 4.9(15)nf	12 p103
2N1195 Mesa (2 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) (-94%) @ 2.9(15)nf	12 p104-105
2N1908, Alloy diff. F_T 20 Mc(min) (2 ea)	7.5(9)	1(16) (E>0.1Mev)	Failed @ 4.8(13)nf	10 p65
Western Electric Co., Inc.				
2N599, Diff. Low Power, Hi-speed Switching, Epitaxial (10 ea)		1.4(15) (E>0.1Mev)	Igain (-5.15%) βV_{CBO} (-77%)	19 p51,53,54
2N599E, Epitaxial Switching (10 ea)		1.4(15) (E>0.1Mev)	Igain (-14.4%) βV_{CBO} (-58.4%)	19 p51,53,54

2.30 **TRANSISTORS**

2.30.2 **SILICON**

2.30.2.1 **NPN**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
Cyrstalonics, Inc.				
C652 (Hi Resistance) Field Effect Device (2 ea.)		6.8(14) (E>0.48 ev)	94% decrease in Mutual Conduction	62 Fig. 2
C652 (Low Resistance) Field Effect Device (3 ea.)		6.8(14) (E>0.48 ev)	83% decrease in Mutual Conductance	62 Fig. 2
Fairchild Semiconductor, Corp.				
2N699, DD Planar. f_T 50 Mc (Min) (3 ea)	1(9)	1(16) (E>0.1 Mev)	Failed @ 4.8(13)nf	10 p. 66
2N706, Mesa, (3 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) (-100%) Failed	12 p. 86-88
2N708, Planar F_T 60 Mc(Min) (3 ea)	~1(8)	8.3(14) (E>0.1 Mev)	$\beta/\beta o$ (-95%)	10 p. 54
2N708, Planar F_T 60 Mc(Min) (1 ea)		2.6(13) (E>0.1 Mev)	β = 34% of βo	36 Fig. 24
2N708, Planar F_T 300 Mc (Min) (2 ea)	7.5(9)	1(16) (E>0.1 Mev)	$\beta/\beta o$ (-80%) @ 1.8(14) nf	10 p. 63
2N709, Planar F_T 600 Mc (Min) (2 ea)	~1(8)	1(15) (E>0.1 Mev)	$\beta/\beta o$ (-85%)	10 p. 54
2N709, Planar F_T 600 Mc(Min) (1 ea)		5(14) (E>0.1 Mev)	β = 20% βo	36 Fig. 24
2N718A, DD Planar, F_T 300 Mc(Min) (2 ea)	7.5(9)	1(16) (E>0.1 Mev)	$\beta/\beta o$ (-95.7%) @ 2.2(14) nf	10 p. 63
2N718A, DD Planar, F_T 60 Mc(Min) (1 ea)	1(9)	1(16) (E>0.1 Mev)	$\beta/\beta o$ (-34.3%) @ ~5(7)ergs/gm-(C)	10 p. 60
2N917, DD Planar, F_T 500 Mc (Min)(3 ea)		1(15) (E>0.1 Mev)	$\beta/\beta o$ (-90%)	10 p. 53

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Fairchild Semiconductor Corp. (Cont.)				
2N917 (Cont.)				
" (1 ea)		5(14) (E>0.1Mev)	β = 20% of β_o	36 Fig. 24
2N1613, DD Planar, F_T 60 Mc(min) (2 ea)	~2(6)	2.2(13) (E>0.1Mev)	β/β_o (-80.4%)	10 p52
" (2 ea)	5(9)	1(16) (E>0.1Mev)	β/β_o (-92%) @ 2.4(14)nf	10 p64,65
"		2(13) (E>0.1Mev)	β = 9% of β_o	36 Fig. 24
General Electric Company				
2N2193A, Epitaxial Planar, F_T 50Mc(min) (4 ea)	5(9)	1(16) (E>0.1Mev)	Failed @ 2(14)nf	10 p64,57
2N2193A, Sandwich Construction (2 ea)		3(12) (E>0.1Mev)	β = 20% of β_o	53 p2
Motorola Semiconductor Products, Inc.				
2N707A, DD Epitaxial Mesa, F_T 70Mc(min) (2 ea)	~1(6)	3.5(13) (E>0.1Mev)	β/β_o (-41%)	10 p52
2N707A, Mesa, F_T 500 (1 ea)		3(13) (E>0.1Mev)	β = 65% of β_o	36 Fig. 24

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Motorola Semiconductor Products, Inc. (Cont.)				
2N834, Epitaxial Mesa (2 ea)	1.8(10)	7.5(15) (E >1Mev)	β/β_o(dc) Failed	12 p97,98
Pacific Semiconductors, Inc.				
PT 901, 10 Amp (2 ea)		3.2(14) (E>0.1Mev)	Ic (-48%) @ 1.8(13)nf	17 p63, 98
PT 955, Triple diff. Mesa, (Graded 2N1902) F_T 50Mc(min) (1 ea)	7.5(9)	1(16) (E>0.1Mev)	β/β_o (-68.7%) @ 3.3(13)nf	10 p65
" (1 ea)	8(9)		β/β_o No change	10 p62
EM-13531-A1 (Graded 2N1259) F_T 160Mc(min) (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_o (-100%), Failed @ 3.3(14)nf	10 p55
EM 13531-A1 (Graded 2N1613) 200Mc (2 ea)		4(12) (E>0.1Mev)	β = 75% of β_o	53 p2
EM74706-U, Triple diff. Mesa, (Graded 2N1893) 50Mc(min) (2 ea)	8(9)		β/β_o (-52.5%) @ ~8(7)ergs/gm-(C)	10 p60
" (2 ea)	7.5(9)	1(16) (E>0.1Mev)	β/β_o (-91.5%) @ 1.3(14)nf	10 p63

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Silicon Transistor Corporation				
2N1722, diff. F_T 1Mc (min) (2 ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 9(12)nf	10 p58
" (1 ea)		2(12) (E>0.1Mev)	β = 20% of β_o	53 p 2
Texas Instruments, Inc.				
TI605 (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_o (-93%) @ 2(13)nf	10 p52 36 Fig. 24
2N706A, Mesa (3 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) Failed	12 p89-92
2N753, Mesa (3 ea)	1.8(10)	7.9(15) (E>1 Mev)	β/β_o(dc) Failed	12 p93-96
2N1717, Triple diff. Mesa F_T 16Mc(Min)(4ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 1.2(14)nf	10 p56, 64
" (2 ea)		3(12) (E>0.1Mev)	β = 20% of β_o	53 p2
2N1722, Triple diff. Mesa F_T 10Mc(min)(2ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 5.7(13)nf	10 p58
" (2 ea)		2(12) (E>0.1Mev)	β = 50% of β_o	53 p2
2N1936, Triple diff. Mesa, F_T 7Mc(min)(2ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 7.7(13)nf	10 p56
"		2(12) (E>0.1Mev)	β = 50% of β_o	53 p2

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (NPN)	DESIGN ALLOWABLES ergs/gm-(C)	n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Western Electric Co., Inc				
2N1060, Epitaxial Switching (10 ea)		2.2(14) (E>0.1Mev)	Igain (-28.4%) @ 6.5(13)nf	18 p47,51
2N1060E, Epitaxial (10 ea)		2.2(14) (E>0.1Mev)	Igain (-27.5%) @ 2.1(14)nf	18 p47,51
2N1675 double Diff. 50W, 10 Amp (5 ea)		2.1(13) (E>0.1Mev)	Igain (I_c = ½A)(-15%) @ 2(13)nf	17 p63,78
2082 (prototype of 2N1675) (15 ea)		3.2(14) (E>0.1Mev)	Igain (I_c = 0.1A) -20% @ 1.8(13)nf	17 p63,74

2.30 TRANSISTORS

2.30.2 SILICON

2.30.2.2 PNP

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (PNP)	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)}$	$\frac{n}{cm^2}$		
Fairchild Semiconductor Corp.				
2N869, Planar DD, F_T 100Mc (Min) (2 ea)	1(9)	1(16) (E>0.1Mev)	Failed @ 2(13)nf	10 p43
" (1 ea)		4.4(14) (E>0.1Mev)	β = 4% of β_o	36 Fig. 24
2N1132, diff., F_T 60Mc (min) (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_o (-93%) @ 3.4(13)nf	10 p54
2N1132, Mesa, F_T 100Mc (1 ea)		3(13) (E>0.1Mev)	β = 12% of β_o	36 Fig. 24
Hughes Aircraft Co.				
EM 74709, DD Mesa, (Graded 2N1259) F_T 40Mc (min) (2 ea)	5(9)	1(16) (E>0.1Mev	β/β_o (-64.3%) @ 4.8(13)nf	10 p66
" (2 ea)		1(13) (E>0.1Mev)	β = 60% of β_o	53 p2
Philco Corporation				
2N861, Precision Alloy, F_T 75Mc (min) (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_o (-88%) @ 2.3(13)nf	10 p53
" (1 ea)		3.4(13) (E>0.1Mev)	β = 14% of β_o	36 Fig. 24
2N2187, Precision Alloy, F_T 22Mc(min) (2 ea)	1(9)	1(16) (E>0.1Mev)	β/β_o (-91%) @ 1.8(13)nf	10 p52

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Transistors, Silicon (PNP)	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Philco Corporation (Cont.)				
2N2187 (Cont.)				
" (1 ea)		4(13) (E>0.1Mev)	β = 6% of β_o	36 Fig. 24
Texas Instruments, Inc.				
2N1385 Mesa (1 ea)	1.8(10)	7.9(15) (E>0.1Mev)	β/β_o(dc)(- 92%)	12 p107
Experimental, Field Effect Device	5.9(9)	2.9(15) (E>1 Mev)	Gm(umhos)(-98.2%) Gm/Gm_o (-98%)	12 p85

2.31 **TUBES, ELECTRON**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
OA2WA				
Gaseous, Voltage Rectifier				
CBS (Hytron) (3 ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 30 ma dc (+1.6%) @ 2.5(14)ne	1 p435
RCA (3 ea)	"	"	Plate V @ 30 ma dc (+5.5%) @ 2.4(14) ne	1 p435
OB2WA				
Miniature Voltage Regulator				
Raytheon (3 ea)	3.5(10)	1.2(15) ne 1.2(18) nt	Plate V @ 30 ma dc (-2%) @ 2.5(14) ne	1 p444
Sylvania (3 ea)	"	"	Plate V @ 30 ma dc (< 1%)	1 p444

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
0Z4				
Full-wave Gas, Cathode Rectifier				
Raytheon (6 ea)	1.6(10)	5.4(14)ne 5.4(17)nt	Plate I (+17.2%) @ 1.1(13)ne	1 p449
1AD4				
RF Sharp Cut-off Pentode				
Raytheon (3 ea)	3.4(10)	1.9(15)ne 1(18) nt	Plate I (+50%) @6.5(14) ne	1 p453-461
Tung-Sol (3 ea)	"	"	Plate I (-50%) @ 5.8(14) ne	"
1B35A				
Gas Switching Tube (ATR)				
Bomac & Sylvania (Static)	3.8(10)	4.5(13)nf 1.4(18)nt	Cracks in RF window	2 p390

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT **Tubes, Electron**	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>1B63A</u>				
Gas Switching Tube TR (Band Pass)				
Bomac (1 ea)	3.1(9)	1.1(15)ne 7.3(17)nt	**Insertion Loss (-73%) @ 2.3(13) ne**	2 p394
Bomac (1 ea)	6.5(9)	2.4(15)ne 1.5(18)nt	**Keep-Alive I intermitten, RF window cracked**	2 p395
Sylvania (2 ea)	6.5(9)	2.4(15)ne 1.5(18)nt	**Keep-Alive I - Failed @ 5(13)ne, RF window cracked**	2 p395
Sylvania (2 ea)	3.1(9)	1.1(15)ne 7.3(17)nt	Insertion Loss (-88%) @ 1.9(14)ne	2 p394
<u>1Z2</u>				
Half-wave Hi-vacuum Rectifier				
Chatham (6 ea)	3(10)	1(15)ne 1(18)nt	**Rectifier Operation in ma dc (+7.3%) @ 7.3(13)ne**	1 p489

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
VG 1 A Ionization Gauge with Pyrex Glass (1 ea)		6.6(16) NVT	Completely Shattered	49 p 11, 7
with Type 008 lime glass (1 ea)		3.7(15) NVT	Discolored Prepressure reading 10^{-6}mm but weld opened on collector in-pile	49 p 7, 12
with type 7720 Nonex Glass (1ea)		3.7(15) NVT	Pressure reading changes from 10^{-6}mm to $5x10^{-3}$mm	49 p 7, 12
with type 1723 alumino silicate glass (1 ea)		3.7(15) NVT	Pressure reading changes from 10^{-6}mm to $3.7x10^{-3}$mm	49 p 7, 12

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
LC-2 Ceramic Power Tetrode				
Eitel-McCullough(4 ea)	3.5(9)	1.3(15)ne 8.2(17)nt	Excessive Screen I, 2 failed in Grid V	2 p555
2C39 UHF Triode (hi-mu)				
Eitel-McCullough(2ea)	7.2(9)	6.7(14)ne 3.7(17)nt	Failed @ 1.7(13)ne due to glass fracture	2 p474
G.E. (Ceramic) (2 ea)	"	"	Plate I (-6.8%) @ 5.3(14)ne, no failures	"
Machlett (2 ea)	"	"	Failed @ 1.7(13) ne due to glass fracture	"
2C40 UHF Triode				
G.E. (6 ea)	4.7(10)	1.7(15)ne 1.6(18)nt	Plate I (-0.118%) Transconductance (-0.7%) @ 4.9(14)ne 1 failed in-pile	1 p494-501

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT **Tubes, Electron**	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
2D21W/5727				
Thyratron-Xenon gas				
G. E. (3 ea)	4.1(10)	2.6(15)ne 1.3(18)nt	Output V (-13%)@ 7.4(14)ne, deionizing time (-40%)@ 9(14)ne 1 failed in pile	2 p414-421
RCA (3 ea)	"	"	Output V (-3.5%) and deionizing Time (+25%) @ 2(14) ne 1 failed in pile	"
Tung-Sol (6 ea) (3 ea) with Cadmium Shields	1.2(11)	2.4(16) (E>0.5 Mev)	Deionizing Time (+14%), 1 failed Plate V (-9%) @ 3.2(15)nf	6 p27, 35, 53
2K50				
Reflex Klystron, K-Band 23.5→ 24.5KMC				
Bendix (3 ea)	2.5(8)	5.2(13)ne 3.5(16)nt	Failed in-pile immediately due to glass fracture	2 p400-405

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
3B28				
Half-Wave Xenon gas Rectifier				
Chatham (1 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Load I - (+5.3%) @ 3.8(14)ne	2 p450
Chatham (1 ea)	3.2(9)		Output I (+6.2%) @ 6.7(8) ergs/gm-(C)	2 p610
Electronic Enterprises (1 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Load I - failed @ 5.4(14) ne due to glass fracture	2 p450
RCA (1 ea)	3.2(9)		Output I (+11%) @ 2.1(9)ergs/gm-(C)	2 p610
RCA (2 ea)	2.8(10)	1.1(15)ne 6.3(17)nt	Both failed in-pile due to glass fracture	2 p450
United Electronics (2 ea)	"	"	One failed in-pile due to glass fracture	2 p450
3CX100A5				
Ceramic Hi-Mu (UHF) Triode				
Eitel-McCullough(3ea)	1.5(10)	3.8(16) (E>0.5Mev)	Cathode V (+800%) @ 3.1(15)nf, Control Grid I (+133%) @ 2.9(16)nf, Survived Irradiation	6 p27,50,53

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
3D21B Pulsed Modulator Pentode				
CBS-Hytron (3 ea)	1.3(11)	3.8(16) (E>0.5Mev)	Transconductance (-14.5%), Plate V (+39%), Test Leads shorted in-pile on all samples	6 p27,46,53
3E29 Dual Tetrode				
RCA (6 ea) (3 ea cadmium Shielded)	1.2(11)	2.4(16) (E>0.5Mev)	Transconductance (+11%) @ 2.2(15)ne, Glass fracture caused failure on 3 tubes in-pile	6 p27,31,53
4D21 Transmitting Type Tetrode				
Lewis & Kaufman (2 ea)	1.4(9)	3.1(14)ne 1.2(17)nt	Grid V @ 75 ma dc (-250%) @ 1.7(13)ne	1 p511-524
Penta Labs (1 ea)	"	"	Grid V @ 65 ma dc (failed @ 1.9(14)ne)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
4J52A Pulsed Magnetron Frequency - 9375 Mc				
Litton Industries(2ea)	4(7)	1.1(13)ne 1(16)nt	Both failed due to glass fractures	2 p406
5C22/HT-415 Hydrogen Thyratron				
Kuthe Labs (3 ea)	1.8(9)	4.9(14)ne 3.5(17)nt	Plate I (-10%) @ 1.9(12)ne, All failed @ 3.8(14)ne due to glass fracture	2 p427-430
5R4WGA Duodiode				
Tung-Sol (4 ea)		7.8(16) NVT	All cracked	49 p11

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5Y3WGTA				
Full-Wave Rectifier				
CBS-Hytron (3 ea)	3(10)	1.2(15)ne 1(18)nt	Output I (-1.3%) @ 3.8(14)ne	2 p461
Sylvania (3 ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Output I (-2.2%) @ 1.2(13)ne	2 p460
6AG7Y				
Power Amplifier, Pentode				
G.E. (3 ea)	2.8(9)	2.1(15)ne 9.4(17)nt	Plate I (+7.1%) and Transconductance (+8.5%) @ 7.6(14)ne	1 p525-536
RCA (3 ea)	"	"	Plate I (+14.4%); Transconductance (+10.5%) @ 7.6(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
6AK5/5654/6096 Sharp Cutoff, Miniature Pentode				
G.E. (1 ea)	3(10)	1.4(15)ne 1(18)nt	Plate I (+13%) @ 7(14)ne, Transconductance (-7%) @ 1.7(13)ne	1 p537-547
Raytheon (2 ea)	3(10)	"	Plate I (+36%) @ 1.4(14)ne Transconductance (-10%) @ 1.1(14)ne	"
RCA (2 ea)	"	"	Plate I (+19%) @ 1.4(14)ne Transconductance (-12%) @ 9.2(14)ne	"
Sylvania (1 ea)	"	"	Plate I (+14%) @ 2.9(13)ne, Transconductance (-12%) @ 2.9(13)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>6AL5WA</u>				
Receiving Twin Diode Type				
CBS(Hytron) (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%), Emission I(+19%) @1(14)ne	1p 548-557
GE (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I (+20%)	1p 548-557
RCA (2ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(-1%)@ 2.1(14)ne, Emission I(+200%)	1p 548-557
Sylvania (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I(+10%)@ 1(14)ne	1p 548-557
Tung-Sol (1ea)	2.2(10)	1.7(15)ne 1.2(18)nt	Output V(0.0%) Emission I(+20%)@ 1.6(15)ne	1p 548-557
<u>6AU6WA</u>				
Sharp Cutoff Min-ature RF Pentode				
GE (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(-8%)@ 4.8(14)ne Transconductance (+3.3%)@ 2(14)ne	1p 558-568
Sylvania (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(+12%)@ 1.4(15)ne Transconductance (+5%)@ 1.2(15)ne	1p 558-568
Tung-Sol (2ea)	3(10)	1.9(15)ne 1 (18)nt	Plate I(-23%)@ 1.3(15)ne Transconductance (-14%)	1p 558-568

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>6BE6/5750</u> Miniature Pentagrid Converter				
GE (6ea)	3.3(10)	1.1(15)ne 1.1(18)nt	Plate I(+5.9)% @ 9(13)ne Screen I(-6.1%)@ 8.1(14)ne Grid V(-14%)@ 3.1(14)ne	1p 569-579
<u>6C4</u> Hi Freq. Medium-Mu Triode				
GE (2ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-31%)@ 1.4(14)ne Emission I(-30%)@ 1.4(14)ne	1p 580-589
RCA (2ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-48%)@ 5.9(14)ne Emission I(-35%)@ 5.6(14)ne	1p 580-589
Tung-Sol (2 ea)	3.2(10)	1.1(15)ne 1.1(18)nt	Plate I(-30%)@ 7.1(14)ne Emission I(-23%)@ 2.4(14)ne	1p 580-589
<u>6L6WGB</u> Beam Power Amplifier				
Tung-Sol (6ea)	4.6(10)	3 (15)ne 1.4(18)nt	Plate I(+33%)@ 1.9(15)ne Screen I(-24.4%)@ 8.1(14)ne, believed gassy	2p 602-606

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
12AT7WA				
Twin Triode (Miniature)				
GE (3ea)	4.4(10)	2.9(15)ne 1.4(18)nt	Plate I(+70.8%)@ 3(14)ne gassy	2p 501-504
Sylvania (3ea)	4.4(10)	2.9(15)ne 1.4(18)nt	Plate I (+38%)@ 1.1(15)ne gassy	2p 501-504
12AU7/6189				
Twin Troide (Miniature)				
GE (3ea)	3.2(10)	1.4(15)ne 1.1(18)nt	Plate I(-24.5%)@ 1.5(14)ne	2p 498-500
Sylvania (3ea)	3.2(10)	1.4(15)ne 1.1(18)nt	Plate I(-32.2%)@ 1.5(14)ne	2p 498-500
CD-16				
Twin Troide (Ceramic)				
Eitel-McCullough (6ea)	3.5(10)	2.1(15)ne 1.2(18)nt	Plate I(+28.5%)@ 1.5(15)ne	2p 506
CD-18				
Miniature Sharp Cut-off Pentode (Ceramic)				
Eitel-McCullough (4ea)	3.5(10)	1.5(15)ne 1.2([illegible])[illegible]	Plate I(+66.7%)@ 2.9(14)ne, 1 Failure	2p 569-573

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
SK-221F				
Reflex Klystron				
Sylvania (2ea)	8.5(10)	6.2(16) (E>1Mev)	freq.(+0.16%) power output (± 11.1%)	30p 83-90
371B				
HiVacuum Half-Wave Rectifier				
Electronic Enterprises (3ea)	1.1(9)	5.1(14)ne 2.7(17)nt	Plate I(-88%) 1 Failed in-pile due to glass fracture	2p 453-458
Electronic Enterprises (1ea)	4(9)		Plate I(-2.3%)@ 6.9(8)ergs/gm-(C)	2p 611
United Electronics (1ea)	4(9)		Plate I(-2.4%)@ 6.9(8)ergs/gm-(C)	2p 611
United Electronics (3ea)	1.1(9)	5.1(14)ne 2.7(17)nt	Plate I(+72.5%)@ 2.9(13)ne, 2 failed in-pile due to glass fracture	2p 453-458
4-65A				
Transmitting Tetrode				
Eitel-McCullough (6ea)	~8.2(9)	~8(13)ne ~8(16)nt	Grid V - all tubes failed in pile due to glass fracture	1p 590-595

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
<u>583</u> Hi-Vacuum, Clipper, Diode United Electronics (6ea)	2(9)	3.9(14)ne 4.4(17)nt	Plate I(+102%)@ 1.1(14)ne, all had fractured envelopes	1p 596-605
<u>BL800A</u> Klystron Bomac (3ea) (2ea with cadmium shields)	6.8(10)	3.5(16) (E>0.5 Mev)	Beam I(±5%) freq.(-50%) power out (+75%) all survived but silicon rubber anode caps deteriorated	6p 27, 39, 53
<u>829B</u> Push-Pull RF Beam Power Amplifier RCA (6ea)	2(10)	2.4(14)ne 1.4(17)nt	all failed in-pile due to glass fracture	1p 606-612
<u>SN-2146B</u> Metal-Ceramic Pentode Sylvania (5ea)		8.8(15) (E>0.5 Mev)	no change in tube characteristics noted	35p 10.77-81

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs/gm-(C)	 n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
SN-2225A				
Twin-Triode (Ceramic)				
Sylvania	6.3(10)	1.6(16) (E>0.5 Mev)	Large Grid I increase, probably not suitable for Nuclear use	35p 10.73-77
5517				
Half-Wave Rectifier				
Raytheon (5ea)	2.3(9)	6.8(14)ne 8.5(17)nt	Cathode I (+10.4%)@ 4.3(12)ne	2p 447-449
5636				
Subminiature, dual-control Pentode				
GE (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-52.7%) & Screen I(-57.2%)@ 3.1(13)ne	2p 586-591
Sylvania (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-32%) & Screen I(-37%)@ 3.1(13)ne	
Tung-Sol (2ea)	3.8(10)	2.4(15)ne 1.2(18)nt	Plate I(-29%) & Screen I(-35%)@ 3.1(13)ne	2p 586-591

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5639 Subminiature Video Amplifier; Pentode				
Raytheon (3ea)	4.5(10)	2.5(15)ne 1.6(18)nt	Plate I(+16.4%)@ 1.5(15)ne	2p 557-561
Sylvania (3ea)	4.5(10)	2.5(15)ne 1.6(18)nt	Plate I(-17.4%)@ 1.7(15)ne	2p 557-561
5643 Subminiature Thyratron Gas Tetrode				
Sylvania (6ea)	1.1(10)	9.1(14)ne 4.8(17)nt	Plate I(-3.4%)@ 1.5(14)ne, two failed in-pile	1p 613-620
5651 Voltage Reference Tube				
Raytheon (3ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 3.5 mAdc (+5%) @ 9(14)ne,	1p 621-629
RCA (3ea)	3.5(10)	1.2(15)ne 1.2(18)nt	Plate V @ 3.5 mAdc (+2.5%) @ 8.3(14)ne	1p 621-629

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5670				
Miniature Medium-Mu, Twin Triode				
GE (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+36%)@ 3.7(14)ne, gassy	2p 518-525
Sylvania (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+28.5%)@ 2(15)ne, gassy	2p 518-525
Tung-Sol (2ea)	4.1(10)	2.7(15)ne 1.3(18)nt	Plate I(+66.6%)@ 2(15)ne, gassy	2p 518-525
5687				
Miniature, Low-Mu, Twin Triode				
Tung-Sol (6ea)	3.1(10)	1.8(15)ne 1 (18)nt	Plate I(-22.2%)@ 1.3(15)ne	2p 508-510
5702				
Sharp Cut-off Pentode				
Raytheon (12ea)	3.1(9)	7.6(13) (E>2.9 Mev)	Plate I(-5%)@ 4.1(12)nf	22p 3, 46
Raytheon (12ea)	3.9(10)	8.6(15) (E>2.9 Mev)	Plate I(+6%)@ 1.4(15)nf	23p 19, 32

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs/gm-(C)	DESIGN ALLOWABLES n/cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5703WA				
Subminiature Triode				
Raytheon (6ea)	2.9(10)	1.9(15)ne 9.4(17)nt	Cathode I(-4.7%)@ 3.7(14)ne, Transconductance (-24%)@ 8.3(14)ne	2p 483-486
5718				
Subminiature Triode				
GE (1ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(+17.5%)@ 7.6(13)ne	1p 630-636
RCA (2ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(-18%)@ 6.6(14)ne	1p 630-636
Sylvania (2ea)	3.6(10)	1.2(15)ne 1.2(18)nt	Plate I(-13.8%)@ 8.3(14)ne	1p 630-636
5719				
Subminiature Triode				
GE (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(+12.5%) 3.6(14)ne, Transconductance (-12.4%) @ 1.3(15)ne	2p 487-495
RCA (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(-14%)@ 1.3(15)ne Transconductance (-16%)@ 1.3(15)ne	2p 487-495
Sylvania (2ea)	2.5(10)	1.5(15)ne 8.7(17)nt	Cathode I(-25%) & Transconductance (-25%)@ 1.3(15)ne	2p 487-495

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5725/6AS6W Miniature Sharp Cut-off, Dual Control Pentode				
GE (3ea)	4.1(10)	2.6(15)ne 1.4(18)nt	Plate I(-20.7%) & Screen I(-28%) @ 2(15)ne	2p 581-585
Tung-Sol (3ea)	4.1(10)	2.6(15)ne 1.4(18)nt	Plate I(-22.8%) & Screen I(-45.4%)@ 2(15)ne	2p 581-585
5744WA Subminiature Hi-Mu Triode				
Raytheon (6ea)	4(10)	2.4(15)ne 1.3(18)nt	Plate I(-19%)@ 6.8(13)ne	2p 480-482
5751WA Miniature Hi-Mu Twin Triode				
GE (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+50%)@ 1.8(15)ne	2p 511-517
Sylvania (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+50%)@ 1.8(15)ne	2p 511-517
Tung-Sol (2ea)	3.8(10)	2.5(15)ne 1.2(18)nt	Plate I(+57.1%)@ 1.5(15)ne	2p 511-517

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
5814WA				
Miniature Medium-Mu Twin Triode				
G.E. (1 ea)	4.3(10)	1.8(15)ne 1.5(18)nt	Plate I(-33.9%) at 9.2(14)ne, possibly gassy	2 p 527-533
Sylvania (2 ea)	"	"	Plate I (-25%) at 9.1 (14)ne	"
Tung-Sol (2 ea)	"	"	Plate I(+18%) at 7.4(14)ne	"
5819				
Photo-Multiplier				
RCA	2.2(7) ergs/gm -(C)-hr		+0.3 ma Anode current	9 p 91
5829				
Dual Diode				
Raytheon (12ea)	3.1(9)	7.6(13) (E>2.9Mev)	I_p/E_p Ratio (0.0%)	22 p 3, 48
Raytheon (12ea)	3.9(10)	8.6(15) (E>2.9Mev)	Plate I (+ 1%) at 2.9(15)nf	23 p 19, 33

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
5840 (6205) Subminiature Sharp-cutoff Pentode				
GE (2 ea)	6.6(10)	4.4(15)ne 2.1(18)nt	Plate I(+19.2%) and screen I(+16%) @ 2.4(12)ne, gassy	2 p 574-580
RCA (2 ea)	"	"	Plate I(+22.4%) and screen I(+15%) @ 2.4(12)ne	2 p 574-580
Sylvania (2 ea)	"	"	Plate I (+25.6%) and screen, I(+18.2%) @ 2.4(12)ne, gassy	"
5876 Subminiature pencil Type, UHF Triode				
RCA (6 ea)	5.9(10)	3.3(15)ne 2.1(18)nt	Plate I(-19%) at 1.7(15)ne, all gassy	2 p 477-479
5896 Subminiature dual diode				
GE (1 ea)	3.7(10)	1.2(15)ne 1.2(18)nt	Output V (-0.5%) at 8.6(13)ne, Emission I (-28%) at 1.1(15)ne	1 p 648-659
Sylvania (3ea)	"	"	Output V(-1%) at 7.6(13)ne, Emission I (+15%)	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs/gm-(C)	$\frac{n}{cm^2}$		
<u>5899A</u> **Subminiature** semi-remote cutoff Pentode				
GE (2ea)	4.8(10)	3.2(15)ne 1.6(18)nt	Plate I(/21%) at 3.6(14)ne, Screen I (/25%) at 2.5(15)ne	2 p 562-568
Sonotone (2 ea)	"	"	Plate I(-30%) at 2.5(15)ne, Screen I (-13.6%) at2(15)ne, All failed to Survive Irradiation	"
Sylvania (2ea)	"	"	Plate I(-7%) and Screen I (-8.3%) at 7.2(14)ne	"
<u>5902</u> Subminiature Pentode (Beam Pwr.)				
GE (3ea)	3.3(10)	2.6(15)ne 1.4(18)nt	Plate I(-9.1%) at 1.4(14)ne, Screen I (-19%)	1 p 660-671
" (3ea)	3.1(9)	7.6(13) (E>2.9Mev)	Plate I (/5%) at 2.2(13)nf	22 p 3, 44
GE and Sylvania (12ea)	3.9(10)	8.6(15) (E>2.9Mev)	Plate I(/5%) at 6.6(15)nf	23 p 19,30
Sylvania (6ea)	3.1(9)	7.6(13) (E>2.9Mev)	Plate I(/5%) at 2.2(13)nf	22 p 3, 44
" (3ea)	3.3(10)	2.6(15)ne 1.4(18)nt	Plate I(-13%) Screen I (-19%) at 1.9(15)ne	1 p 660-671

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	ergs / gm-(C)	n / cm^2		
5903 Dual diode (UHF) Sylvania (3ea)	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Turned Brown but no other Damage	35 p 10.71-73
5907 Remote Cut-off Pentode Sylvania (3ea)	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Brown, No other damage	35 p 10.71-73
5908 Sharp Cut-off, dual control pentode Sylvania (3ea	1.6(9)	2.5(14) (E>0.5Mev)	Envelopes Brown, No other damage	35 p 10.71-73
5993 Miniature, full-wave, hi-vacuum rectifier Bendix (6 ea)	3(10)	1.3(15)ne 1(18)nt	Output I(-1.3%) at 1.4(13)ne, All survived	2 p 463

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>6005/6AQ5</u>				
Miniature beam power pentode				
GE (6ea)	3.6(10)	1.6(15)ne 1.3(18)nt	Plate I(-37%) at 1(15)ne, Screen I (+16.7%) at 3.5(14)ne one failed in-pile	2 p 593-595
<u>6021</u>				
Subminiature Medium Mu twin triode				
GE (1ea)	3.7(10)	2.3(15)ne 1.2(18)nt	Plate I(+37%) at 7.3(14)ne	2 p 534-536
Raytheon (2 ea)	"	"	Plate I(+180%) at 3.7(14)ne, gassy	"
Sylvania (2 ea)	"	"	Plate I(+61.4%) at 1.7(15)ne	2 p 534-536
" (11ea)	3.1(9)	7.6(13) (E>2.9Mev)	I_p/E_p Ratio(+5%) at 1.8(12)nf	22 p 3, 47
GE, Raytheon and Sylvania (12 total	3.9(10)	8.6(15) (E>2.9Mev)	Plate I(+ 3%) at 2.7(15)nf	23 p 19, 31

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
6080				
Low-Mu Twin Triode				
RCA (6ea)	2.5(10)	8.2(14)ne 8.2(17)nt	Cathode V (-2.4%) at 2.7(13)ne	1 p 672-679
6111				
Subminiature Med-Mu Twin Triode				
GE (3 ea)		3(17)nt	Tube failed	52 p 8, 17
" (2 ea)	2.9(10)	1.2(15)ne 1(18)nt	Plate I(+11.4%) at 1(15)ne	2 p 546-551
Raytheon (2 ea)	"	"	Plate I (+20%) at 3.8(14)ne	"
Sylvania (2ea)	"	"	Plate I (-21%) at 3.2(14)ne	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)}}$	$\frac{n}{cm^2}$		
<u>6112</u>				
Subminiature hi-mu twin triode				
GE (2ea)	3.6(10)	2(15)ne 1.3(18)nt	Plate I(-45%) at 3(14)ne	2 p 537-543
GE(in circuit with GE 6111) (2 circuits)		3(17)nt	Circuit Failed	52 p 8
Raytheon (2 ea)	3.6(10)	2(15)ne 1.3(18)nt	Plate I(-20%) at 3(14)ne, gassy	2 p 537-543
Sylvania (2ea)	"	"	Plate I(-27.3%) a 3(14)ne	"
<u>6292</u>				
Multiplier Phototube				
Dumont (2ea)	2.27(7) ergs/gm -(C)-hr.		≯ 1.25 ma anode current	9 p 91
<u>6384</u>				
Beam Power Amplifier				
Bendix (9 ea)	4.1(10)	2.5(15)ne 1.3(18)nt	all failed due to glass fractures	2 p 596-601

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
6442 Ceramic Triode GE (5ea)	7(10)	5.5(16) (E>0.3Mev)	No damage	31 p 2-14
F-6867 SHF, intermediate-pwr. Traveling Wave Amplifier Federal Tele. and Radio (2ea)	3.1(9)	8.6(13)ne 6.5(16)nt	Both Failed at 7.2(13)ne	2 p 431-436
7077 Class A ceramic Triode GE (5ea)	7(10)	5.5(16) (E>0.3Mev)	No damage	31 p 14
7296 Ceramic Triode GE		2.2(18)nt	No damage	52 p 17

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
7588 Ceramic Triode GE (4ea)	7 (10)	5.5(16) (E>0.3Mev)	No damage	31 p 14
7895 Metal-Ceramic Nuvistor RCA (4 Tested in 2 circuits)		1.4(18)nt	1 circuit failed at 9.7(17)nt and the other at 1.4(18)nt	52 p 17
Miscellaneous Type MgO Cold Cathode Type Tung-Sol (4 ea)	5(9)	5(16)nf	Three had large signal degradation	28 p 3

2.32 **WIRE, ELECTRICAL**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
<u>Autolite</u> Mil-W-5086, Ag Plated Cu conductor, Silicone Rubber Insulation, 1st Braid Combination of glass fibre and synthetic fibre, 2nd Braid synthetic fiber and heat resistant Lacquer Insulation, Hi-volt. (3 ea)	4.3 (10)	1.8(15)ne	Insulation R, decreased by order ~10	60 p36, 42, 46
<u>Belden Mfg. Co.</u> Mil-W-583, Heavy Beldtherm, Class "B" Insulation (Epoxide-Polyester Resin) Magnet Wire (3 ea)	2.8(10)	8.1(13)ne	Insulation R decreased by order ~100	60 p36, 42, 46, 59
Heavy Nyclad, Nylon & Vinyl-Acetal Insulation, Magnet Wire (3 ea)	3.3(10)	1.1(15)ne	Insulation R decreases factor ~ 10^3	74 p33
Heavy Formvar, Vinyl-Acetal Insulation, Magnet Wire (3 ea)	3.2(10)	1.1(15)ne	Insulation R decreases factor ~ 10^3 @ 1.1(14)ne	74 p31,26
Mil-W-583, Heavy Beldsol, Polyurthane-Disocyanate Insulation (3 ea)	2.8 (10)	8.1(14)ne	Insulation R decreases by order ~ 10^2 immediately	60 p37,43,46 60

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES ergs / gm-(C)	 n / cm^2	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Birnback Radio Co., Inc. Mil-W-16878A #20 AWG, Insulated type E (Teflon) Hi-Temp.	4.3(10)	1.8(15)ne	Insulation R decreased by factor ~ 100	60 p35,46, 42,56
600V, Copper, Aircraft, Shielded by Copper Shield (3 ea)	3.7(10)	1.4(15)ne 1.4(18)nt	Insulation R decreased by factor ~10^4, two shorted in-pile	74 p30
" (3 ea)		2.2(16)ne	Insulation R decreased by factor ~10^5 @ 1.7(16)ne. Two shorted in-pile	74 p42
600V, Copper, Aircraft (3 ea)	4(10)	2.2(15)ne	Insulation R decreased by factor ~10^5@ 1.9(15)ne	74 p26, 39
" (3 ea)		2.2(16)ne	Insulation R decreased by factor ~10^4 @ 1.9(16)ne	74 p42, 27
William Brand Co.				
AWG 22, 19 Strands #34 AWG Tinned Soft Cu, Insulation 0.016" Dow Corning Silastic 80 (10 ft)		4.1(16) (E>0.5Mev)	Cracked and became so Brittle that no tests could be performed	35 p10. 96-100
AWG 22, 7 Strands of #30 AWG, Ag-plated Soft Cu, Insulation 0.031" GE XE-9003A (10 ft)		"	"	"

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	DESIGN ALLOWABLES $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
William Brand Co. (Cont.) AWG 20, 19 Strands of #32 AWG Ag-plated Soft Cu, Insulation 0.016" Silastic 80 (10 ft)		4.1(16) (E>0.5Mev)	Cracked and became so brittle that no tests could be performed.	35 p10. 96-100
AWG 14, 19 Strands of #27 Tinned Soft Cu, Insulation 3/64" GE SE-975 (10 ft)		"	"	"
AWG 14, 19 Strands of #27 AWG Ag-Plated Soft Cu, Insulation 3/64" Silastic 80 (10 ft)		"	"	"
Gavitt Wire & Cable Co. Mil-W-76A, Hook-up Covering "J", Nylon Jacket, Polyvinyl Insulation (3 ea)	3.3(10)	9.6(14)ne	Insulation R decreased by factor $\sim 10^4$ @ 1.9(12)ne	60 p35, 46, 48
" (3 ea)	3(11)	1.1(15)ne	Insulation R decreased by factor $\sim 10^5$ @ 3.8(13)ne. All shorted in-pile	74 p40, 27
Mil-W-76A, Hook-up Covering "B", Glass Yarn Braid, PVC Insulation (3 ea)	3.3(10)	9.6(14)ne	Insulation R decreased by factor $\sim 10^3$ @ 1.8(12)ne	60 p35, 46, 48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	 $\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Gavitt Wire & Cable Co. (Cont.)				
Mil-W-76, Hook-up Covering "BS," Glass Yarn Braid & Cu Shield PVC Insulation (3 ea)	4.2(10)	2.2(15)ne	Insulation R decreased by factor $\sim 10^4$ @ 4.5(13)ne	60 p35, 46, 52
" (3 ea)	3(11)	1.1(15)ne	Insulation R decreased by factor $\sim 10^4$ @ 3.2(13)ne	74 p40, 27
Mil-W-76A, Hook-up Covering "S" Cu Shield PVC Insulation (3 ea)	4.3(10)	2.2(15)ne	Insulation R decreased by factor $\sim 10^4$ @ 1.5(14)ne	60 p35, 46,
Mil-W-76A, Hook-up Covering "U," PVC Insulation (3 ea)	4.1(10)	1.9(15)ne	Insulation R decrease factor $\sim 10^3$ @ 1.8(14)ne	60 p35, 46,
Phelps Dodge Copper Products, Corp.				
Mil-W-583, Magnet Wire, Heavy Thermaleze Single Daglas, Silicone Glass fiber, Dacron Yarn (polyester), Class "B" Insulation (Epoxide-polyester Resin) (Ethylane glycol & Terephthalic Acid Insulation) (3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor ~ 100 @ 9.8(13)ne	60 p36, 42, 46, 59

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES ergs/gm-(C)	n/cm²	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Phelps Dodge Copper Prod. Corp. (Cont.)				
Mil-W-583, Magnet Wire, Heavy Thermaleze, Single Daglas, Silicone Glass fiber, Dacron Yarn (polyester), Class "B" Insulation (Epoxide-polyester Resin)(Ethylene glycol & Terephthalic Acid Insulation) (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 47
Mil-W-583, Magnet Wire, Same as above but has double rather than single Daglas (3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor ~100 @ 9.8(13)ne	60 p36, 42, 46, 59
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27,47
Mil-W-583, Magnet Wire, Single Soldereze, polyurathane, Disocyanate Insulation (3 ea)	2.8(10)	8.1(14)ne	Insulation R decreases by factor ~100 @ 9.8(13)ne	60 p37, 43, 46, 60
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 3.3(12)ne	74 p50, 27
Mil-W-583, Magnet Wire, Heavy Thermaleze "B" Insulation (epoxide-Polyester Resin) (Ethylene glycol & Terephthalic Acid Insulation) (3 ea)	3.6(11)	1.9(15)ne	Insulation R decreases by factor ~100 @ 6.8(12)ne	74 p46, 26
Mil-W-583, Magnet Wire, Single Nyform Combination of Vinyl-Acetal & Nylon Enameled Insulation (3 ea)	"	"	Insulation R decreases by factor ~100 @ 8.4(12)ne	74 p26, 48

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Phelps Dodge Copper Prod. Corp. (Cont.)				
Mil-W-583, Magnet Wire, Heavy Nyform, similar to wire of last item on previous page (3 ea)	4.1(10)	1.5(15)ne	Insulation R decreases by factor ~10 @ 1.6(14)ne	74 p26, 36
" (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 49
Mil-W-583, Magnet Wire, Heavy Formvar, Vinyl-Acetal Insulation (3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 2.4(12)ne	74 p27, 49
Mil-W-583, Magnet Wire, Heavy Formvar, Single Daglas, Glass fibre, Dacron Yarn (Polyester) (3 ea)	4.1(10)	2.2(15)ne	Insulation R decreases by factor ~10 @ 2.3(14)ne	74 p26, 34
Same as above except Single Formvar, & double Daglas(3 ea)	2.6(11)	9.5(14)ne	Insulation R decreases by factor ~100 @ 3.4(12)ne	74 p27, 50

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sprague Products, Inc.				
Mil-W-583, Magnet Wire, Ceroc, Teflon, Inorganic Ceramic & Teflon Insulation (3 ea)	3.5(10)	1.9(15)ne	All Shorted in-pile	74 p48, 26
Mil-W-583, Magnet Wire, Ceroc, Silicone, Inorganic Ceramic & Silicone Insulation (3 ea)	"	"	Two shorted in-pile	74 p 26, 52
Miscellaneous				
Mil-W-16878C, Type (1000V) Extruded Insulation (Teflon - TFE)	1.3(9)	8.7(11)nf 1(12)nt	Very brittle & powdery	8 p117, 114
Mil-W-16878C, Teflon Wire, Single Conductor 1000V, Ag-plated Cu Shield Jacket of Wrapped Teflon, Also twisted pair types	"	"	Flaked off & powdery	8 p117, 114
Mil-W-12349(SIGC) Modified Polyolefin Insulation	"	"	Withstood radiation in good condition	8 p117

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Wire, Electrical	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm-(C)}$	$\frac{n}{cm^2}$		
Miscellaneous (Cont.)				
Mil-W-7139A, Inner Insulation. Two servings of wrapped Teflon. Outer - Two servings of braided fibre - glass impregnated with Teflon	1.3(9)	8.7(11)nf 1(12)nt	Inner was very brittle Outer is in good condition and confines inner	8 p117

3.0 PULSE IRRADIATION DATA

3.1 **AMPLIFIERS**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Amplifiers	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Miscellaneous				
Two Stage Instrument Amplifier (Transistor 2N43A And 2N952)		1 (16)	Amplifier gain (-8%)	211 p 99
Low Level Servo Amplifier (Transistor 3 Type 2N43)		1 (16)	Amplifier gain (-15%)	211 p 99
Mixer or Buffer Magnetic Amplifier (Diodes) 4 Types HD 6006		1 (16)	No effect on amplifier gain	211 p 99

3.2 **CAPACITORS**

3.2.1 **CERAMIC**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Ceramic	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	 $\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Aerovox Corp.				
0.01mf C80AT	3.0 (9)	~9(16)	Capacitance (+1.6%) Diss. factor (+8.7%)	203 p 5, 12,62
Sprague Pdts Co.				
0.01mf Type C46	4.3 (9)	> 1(17)	Capacitance (0%) diss. factor (+4%)	203 p 5
Vitramon, Inc.				
0.0047mf Type VK 20 (2ea)	3.1(9)	~9(16)	Capacitance #1 (+0.22%) Capacitance #2 (-0.11%) Diss. factor (-3.2%)	203 p 5,13,62
Miscellaneous				
0.01mf, 600 VDC Disk Type Ceramic	2.7 (8)		Initial V change (-0.4%)	208 p 83, 109

3.2 CAPACITORS

3.2.2 ELECTROLYTIC

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Electrolytic	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
G.E.				
6 mf, 600 VDC Dykanal C (chlorinated diphenyl) TJU 6060J	4.3(8)		No Electric Breakdown, No capacitance Change	208 p. 83, 114
Sprague Products Co.				
10 mf TVL Type	1.78(9)	~5(16)	2270 Microamp Leakage Current	203 p. 6, 62
40 mf TVL Type	1.02(9)	~3(16)	>>2700 Microamp Leakage Current	203 p. 6, 62
100 mf TVL Type (2 ea)	9.1(9)	~1(16)	569 Microamp Leakage Current	203 p. 6, 62

3.2 **CAPACITORS**

3.2.3 GLASS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Capacitors, Glass	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Corning Glass Works				
0.01 mf Glass Type CY30	3.4(9)	~9(16)	No change in capacitance	203 p. 5, 12, 62
International Business Machines				
0.01 mf Evaporated Glass	4.0 (9)	~1(17)	No change in capacitance. 64 microamp leakage current.	203 p. 6, 62

3.2 CAPACITORS

3.2.4 MICA

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mica	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)-sec}}$	$\frac{\text{n}}{\text{cm}^2\text{-sec}}$		
El Menco				
0.01 mf Ruby Mica	4.3 (9)	>1(17)	Capacitance (-0.02%)	203 p. 12, 62
0.01 mf, 500 VDC Silver-Mica	1.1 (8)		Capacitance (0.15%) Initial V Change (-0.6%)	208 p. 83, 101 109

3.2 CAPACITORS

3.2.5 MYLAR

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Mylar	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	DESIGN ALLOWABLES $\frac{\text{n}}{\text{cm}^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Good-All				
1 mf, 600 VDC Type 613G	2.0 (8)		Capacitance (0±15%)	208 p. 83, 101
Miscellaneous				
Type Polyethylene Terephthalate (Mylar) Capacitor	3.8(8)		Induced conductivity $(\text{ohm-cm})^{-1}$ (1.1×10^{-11})	202 p. 14

3.2 CAPACITORS

3.2.6 PAPER

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Capacitors, Paper	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Cornell-Dubilier Co.				
0.1mf 600 vdc Oil-Impregnated CP28A1EF104K Cub Type	2.7 (8)		Maximum Voltage Change less than 5.4 volts. Capacitance (-3.5%)	211 p. 62 208 p. 83, 101
1 mf 600 vdc Wax-Impregnated Pup Type (6 ea)	1.2 (8)		Initial V Change (-0.7%)	208 p. 83, 101
6 mf - Epoxy Kish' Potting Compound, Pup Type (6 each 1 mf in parallel)	1.1(8)		Maximum Voltage Change = 10.8 volts	211 p. 62
Sprague Products Co.				
0.01 mf Vitamin Q Impregnated	6.3(8)		Capacitance (+7.6%) Diss. factor (-25%)	200 p 12
0.47 mf 400 VDC Vitamin Q Impregnated	2.0 (8)		Capacitance (0±12%)	208 p 83, 101

3.2 CAPACITORS

3.2.7 TANTALUM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Capacitors, Tantalum	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	 $\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sprague Products Co.				
0.01 mf Type 150D	3.7(9)	~1(17)	Capacitance (+0.36%) Diss. factor (-3.2%) Leakage I (26.6 ma)	203 p. 12, 62
0.1 mf Type 150D	3.4(9)	~9(16)	Capacitance (+0.47%) Diss. factor (-10.9%)	203 p. 12, 62
1 mf Type 150D	~3(9)	~7(16)	Capacitance (+0.77%) diss. factor (-13.9%)	203 p. 12, 62
4 mf Type 120D (2 ea)	2.1 (9)	~6.3(16)	Capacitance (+1.2%) Diss. factor (+24%)	203 p. 6, 12, 62
10 mf Type 150D (3 ea)	3.4(9)	~9(16)	Capacitance (+6.1%) Diss. factor (-27.2%) Leakage I (+160 ma)	203 p. 12, 62, 6
10 mf Type 120D (2 ea)	~2(9)	~6(16)	Capacitance (-2.5%) Diss. factor (-21.3%) Leakage I (19.7 ma)	203 p. 6, 12, 62
10 mf Type 109D (4 ea)	3.2 (9)	~7.2(16)	Capacitance (+6.5%) Diss. factor (-19.6%) Leakage I (872 ma)	203 p. 6, 12, 62
12 mf Type 120D	1.8 (9)	~5.8(16)	Capacitance (+3.7%) Diss. factor (-7.2%)	203 p. 12, 62
22 mf Type 150D (2 ea)	~3.3(9)	~7.2(16)	Capacitance (+4.79%) Diss. factor (-3%)	203 p. 12, 62
12 mf Tantalex Type (2ea)	6.5(8)	~2(15)	Capacitance (+0.33%) Diss. factor (+16.66%	200 p. 12

3.3 CIRCULATORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Circulators	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	DESIGN ALLOWABLES $\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sperry - Rand Corporation				
C - Band Coaxial Y - Junction Circulator	2.2 (7)	1.3 (17)	Changes in Output signal levels from the antenna port of the unpotted circulator and the antenna and receiver ports of the potted circulator area less than 0.05db.	212 p. 5-1

3.4 COAXIAL CABLES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Coaxial Cables	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	DESIGN ALLOWABLES $\frac{\text{n}}{\text{cm}^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Phelps Dodge Copper Products				
Air dielectric coaxial cable (Spirafil)	1.2 (7)	7 (16)	The degree of ionization was found to increase when the air pressure was reduced below one atmosphere	212 p. 5-2
Miscellaneous				
Coaxial Cable (Open Circuit) RG-58/u and RG-9A/u.	~7 (9)		RG-58/U. Voltage Pulse of 0.2 → 05 volt is developed during the burst RG-9A/u voltage pulse of 1.0 to 2.0 volts.	204 p. 8
RG-62 Coaxial	~7 (9)		-0.90 induced voltage in cable	210 p. 29
RG-59/u	~7 (9)	1 (16)	0.10 induced voltage in cable & 6.1 induced microamps in cable	211 p. 21
RG-62/u	~7 (9)	1 (16)	-15% capacitance	211 p. 21
RG-58/u Solid Polyethylene dielectric, solid center conductor shield tinned - Cu Braid	9.5 (8)	5.5(16)	Induced I 100 μa @ 1500v Induced I 30 μa no volts applied	205 p. 36-39, 45

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Coaxial Cables	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	 $\frac{\text{n}}{\text{cm}^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
RG-8/u				
Solid polyethylene dielectric stranded center conductor, shield Cu braid	1 (9)	5.9(16)	Induced I @ 1500v applied (600 μa) Induced I, no volts applied (25 μa)	205 p. 39-43, 45

3.5 CRYSTALS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Crystals	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Bulova 300 GAX 161.73 KC	~1(9)		Oscillator Amplitude (-50%) Freq. remained stable	200 p21

3.6 INDUCTORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Inductors	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Ferrite Inductor Mn-Zn	2.8 (9)		Core located at the reactor. No shunt resistance. ΔV Percent = - 42	206 Table III
Ferrite Inductor Mn-Zn	2.8 (9)		Core located outside reactor with a 100KΩ shunt resistance outside the reactor. ΔV = - 58 percent	206 Table III
Ferrite Inductor Ni-Zn	2.8 (9)		No shunt resistance ΔV = - 47% Core located at the reactor	206 Table III
Ferrite Inductor Ni-Zn	2.8 (9)		No shunt resistance ΔV = - 32 percent Core located 60 in. back from the reactor	206 Table III

3.7 ISOLATORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Isolators	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sperry Rand Corporation				
Internal Magnet Coaxial Isolator	2.2 (7)	1.2 (17)	Changes in output signal levels from the potted and un-potted isolators are less than 0.05db.	212 p 5-1

3.8 LIMITERS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Limiters	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Sperry Rand Corp.				
Gyromagnetic Coupling Limiter	3.1 (7)	1.7(17)	Changes in output signal levels from the unpotted and potted limiters are less than 0.05db	212 p. 5-1

3.9 OSCILLATORS

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Oscillators	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Hewlett - Packard				
Model 200 CD	1 (9)	1(12)	Output vanishes for a period of about 30 mil sec	203 p34
Miscellaneous				
22 Kc, Model 1250 A with 3 ea. Type 2N1139 & 2 ea. Type 2N495 Xsistors	3.8(8)	5.5 (15)	Freq. Shift (+26%) Amplitude Shift (-90%)	211 p98-99
22 Kc, Model 1250 A with 3 ea. Type 2N1139 & 2 ea. Type 2N495 Xsistors	1.1 (8)		Freq. Shift (-20%) Amplitude Shift (-30%)	211 p99,97
40 Kc, EMR Model 75B with 2 type 5840 Tubes	3.8(8)	4.9 (15)	Freq. Shift (-4%) Amplitude Shift (-40%)	211 p 98
40 Kc, EMR Model 75B with 2 type 5840 Tubes	1.1 (8)		Amplitude Shift (-7%) Freq. Shift (< 1%)	211 p99, 97
70 Kc, TDI Model 1202A with 4 type 611 Tubes	3.5 (8)	5(15)	Freq. Shift (+20%) Amp. Shift (-60%)	211 p 98
70 Kc, TDI Model 1202A with 4 type 611 Tubes	1.1 (8)		Amp. Shift (-10%) Freq. Shift (+3%)	211 p 99, 97
900 cps. Oscillator with 3 type 2N903 Xistors (6ea)		1 (16)	4 Units failed	211 p 99
40 Kc, EMR Model 75B with types 5840,5718, 5719 Tubes(2 ea)	8.7(8)	1(15)	Center Frequency Shift (-0.6%)	211 p 100
70 Kc, EMR Model 75B with types 5840,5718, 5719 Tubes	8.7 (8)	1(15)	Center freq. Shift (± 0.4%)	211 p 100
Blocking Oscillator Multivibrator (6 ea) with 1N137A & 2N904		1 (16)	3 failed, output amp (-80%)	211 p 99

3.10 **POWER SUPPLIES**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Power Supplies	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{\text{ergs}}{\text{gm-(C)-sec}}$	$\frac{\text{n}}{\text{cm}^2\text{-sec}}$		
Boeing Co. PS-210, 150 VDC				
Transistorized		1 (16)	Power unit went out of specification limits due to changes in transistor parameters	216 p 1 211 p 97
PS-223, 250 VDC Transistorized Power Supply		1 (16)	Output V (0.05V) failed, ripple V (0.3mv)	211 p 97
PS-210, 150VDC Transistors: 1 type 2N 338, 2N 539, & 2N 575		1.4 (16)	Output V (-1.4%) poor regulation ripple V (1 V)	211 p 97

3.11 **RESISTORS**

3.11.1 CARBON COMPOSITION

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Carbon Composition	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Allen Bradley Co.				
0.1 K 2W (3 ea) Unpotted	1.4(9)		Resistance (<1%)	200 p. 7 211 p. 47
1 K, 2W	1.6(9)		Resistance (1.65%)	200 p. 7
1 K, 2W	3.8(8)		Resistance (2.3%)	211 p. 47-49
1.021 K, 2W, paraffin potted	3.8(9)		Resistance (0.3%)	211 p. 47-49
10 K 2W (3 ea)	1(9)		Resistance (4.8%)	200 p. 7
10 K 2W, Unpotted	1.4(9)		Resistance (0.2%)	211 p. 47-49
10 K, 2W, paraffin potted	4.3(8)		Resistance (1.5%)	211 p. 47-49
100 K 2W (3 ea)	1(9)		Resistance (25%)	200 p. 7
100 K	7.4(9)		Resistance (-16%)	201 p. 29
100 K 2W Acrylic potted	2.3(8)		Resistance (2.2%)	211 p. 48
100 K, 2W, paraffin potted	4.2 (9)		Resistance (3.1%)	211 p. 48
1 Meg 2W (3 ea)	1.1(9)		Resistance (75%)	200 p. 7
1 Meg, 2W, Unpotted	2.3(8)		Resistance (5.6%)	211 p. 48
1 Meg, 2W, paraffin potted	8.1(8)		Resistance (30.5%)	211 p. 48
10 Meg 2W Unpotted (1 ea)	1.3(9)		Resistance (87%)	200 p. 7
10 Meg, 2W, Paraffin potted	4.8(9)		Resistance (85%)	211 p. 49

3.11 RESISTORS

3.11.2 CARBON FILM

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistor, Carbon Film	$\frac{\text{ergs}}{\text{gm-(C)-sec}}$	$\frac{n}{\text{cm}^2\text{-sec}}$		
Miscellaneous				
0.1K, 1/2 watt,	~3(9)	2(17)	ΔV(max volts)= 0 $\frac{\Delta R}{R_o}$ = 0 (Applied voltage = 6 volts)	206 p.6
0.1K, 1/2 watt	~3(9)	2(17)	ΔV (max. volts = -0.005 $\Delta R/R_o$ = -0.09 (Applied voltage = 22 volts.	206 p. 6
0.1K, 1/2 watt	~3(9)	2(17)	ΔV(Max. Volts) = 0.005 $\Delta R/R_o$ = -0.04 applied voltate = -45 volts	206 p. 6
0.1K, 1/2 watt,	~3(9)	2(17)	ΔV (max volts)=1.0 $\Delta R/R_o$= 0, Applied voltage=3 vac	206 p 6
1K, 1/2 watt	~3(9)	2(17)	ΔV(max. volts)=0.16 $\Delta R/R_o$ = -1.6. Applied voltage = 45 volts	206 p. 6
1K, 1/2 watt	~3(9)	2(17)	ΔV(max volts)=4.0 $\Delta R/R_o$ = -7.2 Applied Voltage = -200 volts	206 p 6
10K, 1/2 watt	~3(9)	2(17)	ΔV = -0.65 $\Delta R/R_o$ = -21.6% Applied Voltage= 12V	206 p 6
100K, 1/2 watt	2(9)	2(17)	ΔV(max volts) = -4.2 $\Delta R/R_o$ = -147%	206 p 6

3.11 **RESISTORS**

3.11.3 **FILM**

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Resistors, Film	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Corning Glass				
100K Film Resistor	8.7(9)		Resistance(-18%)	201 p. 29
100K Film Resistor	1.1(10)		Resistance (-15%)	201. p. 29
International Resistance Corporation				
100K Metal Film	7.9(9)		Resistance (-14%)	201 p. 29
100K Metal Film	5.9 (9)		Resistance (-15%)	201. p. 29
Victoreen Instrument Co.				
0.1K, 5W Vacuum-Encapsulated deposited Film	3.9(8)		Resistance (11.3%)	200 p. 7

3.11 RESISTORS

3.11.4 WIREWOUND

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Resistors, Wirewound	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
Mepco, Inc.				
10 K, Paraffin Potted	6.0 (8)		1.8% change in resistance	211 p 52
100K, Paraffin Potted	9.4 (8)		13.2% change in resistance	211 p 52
100K	8.7(9)		Resistance (-22%)	201 p 29
1 Meg, Paraffin Potted	8.5 (8)		53.6% change in resistance	211 p 52
1 Meg, Paraffin Potted	7.0 (8)		51.2% change in resistance	211 p 52

3.12 SEMICONDUCTOR DEVICES

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Semiconductor Devices	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
IBM01 (Tunnel Diode) Ge PNP	1.5 (9)		I_{co} (/98%)@ Peak	211 p 14
IN76A Ge Diode	2(8)		Reverse I pulse @ 15V (50 ua) @ 50 V (62 ua)	211 p 18
IN277 Diode	7.2(8)		peak increase I (132 ua)	211 p 18 Table 3
IN254 Alloy-Junction Silicon Diode Rectifier		1 (17)	Increase of 200 to 450 ua from an original reverse (Leakage) I of < 1 ua were observed during first half mil sec. The Amount of Change & subsequent recovery are Neutron dose dependent	210 p 2, 33
IN 629 Si Diode	2 (8)		Forward I pulse @ 0v (11 ua), Reverse I pulse @100v (18ua)	211 p 18
2N 123 Ge PNP	1.5 (9)		I_{co} increase from Pretest value of 0.4 ua to 2800 ua at peak Transient	211 p 14
2N 167 Ge PNP	1.4(9)		I_{co} increases from pretest value of 1ua to 250 ua @peak Transient	211 p 14
IN251 Diode Transitron	5 (9)		Peak Leakage I @ 90°c (40 ua)	201 p 22
IN543 Diode Pacific Semiconductor, Inc.	7 (9)		Peak Leakage I @ 25°c (425 ua)	201 p 23
IN 658 Diode Radio Receptor	~6 (9)		Peak Leakage I @ 25°c (310 ua)	201 p 24
2N335 Si NPN T.I.	2 (9)		I_{co} Peak Transient value(35ua)	211 p 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Semiconductor Devices	$\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$		
2N 335 T. I.	4 (9)		Peak I_{co} (800 ua) B/B_o (Failed)	201 p 7
2N 335 General Electric	1 (10)		Peak I_{co} (360ua) B/B_o (-90%)	201 p 8, 14
2N 335 Si NPN G E	4 (9)		I_{co} Peak Transient (490 ua)	211 p 14
2N 338 Si NPN	1 (9)		Peak I_{co} Transient (540 ua)	211 p 14
2N338 T I	1 (10)		Peak I_{co} (240ua)	201 p 6
2N 338 Si NPN T I	2 (9)		I_{co} Peak Transient (35 ua)	211 p 14
2N 389 Si NPN	1 (9)		I_{co} Peak Transient (12000 ua)	211 p 14
2N 389 TI	1 (6)		B/B_o (-80%)	201 p 15
2N 495 Si PNP Philco	1 (10)		I_{co} Peak Transient (170 ua)	211 p 14 201 p 9
Z 3.9 Zener Diode U.S. Semiconductor,Inc	7.3 (9)		14 mv change in regulation V	201 p 27
IN 1313A Zener diode Hoffman	1 (9)		Knee reverse Characteristics (No change) Min diode V did not return to zero	211 p 19
SV-6 Zener diode Transitron	7.5 (8)		29 mv changes in regulator V	201 p 27
651 C4 Zener diode TI	1 (9)		Knee reverse characteristics (no change) Min. diodes V did not return to zero	211 p 19
SE 6M16 Selenium Diode Rectifier	2 (8)	1 (17)	Leakage I (+60%)	210 p 2,28
IBM 51 Ge PNP	1.4(9)		I_{co} Peak Transient (3000 ua)	211 p 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Semiconductor Devices	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)-sec}$	 $\frac{n}{cm^2-sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
1275 Si PNP	1.5 (9)		I_{co} Peak Transient (66 ua)	211 p 14
HD6008 Si Diode	2 (8)		Current pulse @ 100v (75 ua)	211 p 18

3.13 TUBES, ELECTRON

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	DESIGN ALLOWABLES $\frac{n}{cm^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
<u>0 B 2</u>				
Gas filled voltage regulator				
Westinghouse (2 ea)	1.1 (9)		12.95% Change in Current	200 P. 17
<u>XDIC</u>				
Gas Diode (Firing) V_f = 113v				
GE	~2.8(9)		Diode Bias firing = 88% of V_f	213 P 11
<u>1 P 28</u>				
Photomultiplier				
RCA (1 ea)	1.8(8)		Current Change (8900 ± 500 ma)	211 P. 34

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm-(C)-sec}$	$\frac{n}{cm^2-sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
2D21 Thyratrons G.E. (2 ea)	5.9(8)		9.85% change in tube current. Pulsed radiation caused non-conducting tubes to fire.	200 P. 15
G.E.	2.4 (9)		Critical Grid Voltage = -1.75 volts, applied grid voltage = -2 volts. The tube fired during this burst.	203 p. 23
G.E.	4.1(9)		Critical Grid Voltage = -0.75 volts. Applied grid voltage = -4 volts. The tube did not fire during the burst.	203 p. 23
G.E.	3.7(9)		Critical Grid Voltage = -4 volts. Applied grid voltage = -1.8 volts. The tubes fired during the burst.	203 p. 23

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	DESIGN ALLOWABLES $\frac{n}{\text{cm}^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
XD-100				
Gas firing Diode V_f = 100 V				
G.E.	~2.8(9)		Diode Bias firing = 68% of V_f	213 p. 10
XD-150				
Gas firing Diode V_f = 150 V				
G.E.	~6.5(9)		Diode Bias firing = 58% of V_f	213 p. 12
XD-225				
Gas firing Diode V_f = 225 V				
G.E.	~6.5(9)		Diode Bias firing = 55% of V_f	213 p. 13
XD-300				
Gas firing Diode V_f = 300 V				
G.E.	~6.5(9)		Diode Bias firing = 57% of V_f	213 p. 14
XD-375				
Gas firing Diode V_f = 375 V				
G.E.	~8(9)		Diode Bias firing = 52% of V_f	213 p. 15

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{ergs}{gm\text{-}(C)\text{-}sec}$	$\frac{n}{cm^2\text{-}sec}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
XD-750				
Gas firing Diode $V_f = 750$ V				
G.E.	~8(9)		Diode Bias firing = 62% of V_f	213 p. 16
1724G				
Ceramic Equivalent of 6J6				
Sylvania (Operating under Applied Voltage)		3.8(16)	Signal Attenuation varies with Distance from the reactor. (-33%) @ 3.7 cm from reactor screen.	209 p. 15
Sylvania (No voltage)		3.1(16)	No effect on Tube	209 p. 24
2146 B				
Ceramic Equivalent of 6AQ5				
Sylvania (Operating Under Applied Voltage)		3.8(16)	Tube Output Completed Attenuated for 150 milsec after Burst Tube Behavior varies with distance from Reactor.	209 p. 24

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES $\frac{\text{ergs}}{\text{gm-(C)-sec}}$	 $\frac{n}{\text{cm}^2\text{-sec}}$	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
2225A Ceramic Equivalent of 12AT7				
Sylvania (Operating under Applied Voltage)		3.8(16)	Signal Amplitude attenuated to zero at 250 milsec after burst. Varies with distance from reactor.	209 p. 15
Sylvania (No Voltage)		3.1(16)	No effect on tube	209 p. 24
Z-5312				
Voltage-Tunable Magnetron (VTM)				
G.E. #1697 (air atmosphere)	1.7(9)	1(17)	Power Output (+64%) Freq. (-15 Mc or -0.75%) Anode I (+10 ma, or +107.6%)	205 p. 19-25, 45
G.E. #1697 (Nitrogen Atmosphere)	3.9(8)	~ 7(16)	Power (+64%) Freq. (No change)	225 p. 21
G.E. #1674	2.8(8)	1.6(16)	Freq. (-6 Mc or-0.26% Power output (+33%) Anode I (+3 ma or +20%) for 125 usec. Control Electrode I (+130 ua)	205 p. 31, 45
G.E.	1.5(9)		Negligible Effect on Parameters.	204 p. 53

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT Tubes, Electron	DESIGN ALLOWABLES ergs / gm-(C)-sec	 n / cm^2-sec	BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Z-5337 Voltage Tunable Magnetron GE #193	1.8 (9)	1.1 (17)	Power output (+2.5%) Freq. (Unchanged) Control Electrode I + 75 μa for 200 μsec	205 p. 12-16, 45
Z-5428 Voltage Tunable Magnetron GE #30	9.2 (8)	5.8(16)	Freq. & Power (Unaffected) Anode I (+3 ma or +20%) for 100usec, control Electrode I (+100 μa) for 250 usec.	205 p. 31-35, 45
5636 Triode Sylvania (3 ea)	6.4 (9)		0.98 ma increase in current @ cutoff	201 p. 33
5840 Pentode RCA (3 ea)	1.1 (10)		0.82 ma increase in current @ cutoff	201 p. 33
5896 Duo diode Sylvania (8 ea)	7.8 (8)		Plate I (6%)	200 p. 14

NUCLEAR RADIATION EFFECTS DESIGN ALLOWABLES

MATERIAL OR COMPONENT	DESIGN ALLOWABLES		BASIS FOR DESIGN ALLOWABLES	RADIATION EFFECTS REFERENCE No.
Tubes, Electron	$\frac{\text{ergs}}{\text{gm-(C)-sec}}$	$\frac{n}{cm^2\text{-sec}}$		
6111				
Sylvania (2 ea)	6.8 (9)		1.01 ma increase in current @ cutoff	201 p. 33
6590				
Subminiature Thyratron		1.8(15)ne	83% amplitude decrease	215 p. 58
6690				
Triode		9.8(14)ne	Plate signal (90%) Shift, no permanent damage	215 p. 51
7077				
Ceramic Triode				
GE (4 ea)	9.1 (9)		1.5 ma increase in current @ cutoff	201 p. 33
Unknown		1.8(15)ne	Plate signal (71%) Shift, no permanent damage	215 p. 51

4.0 DESIGN ALLOWABLE REFERENCES

4.1 STEADY-STATE IRRADIATION

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5.0 LIST OF ABBREVIATIONS USED IN DESIGN ALLOWABLES

absolute . . . . abs
alternating-current(as adj.only). . . . . a-c
American wire gauge . . . . Awg
ampere. . . . . amp
ampere-hour . . . . .amp-hr
amplification factor of vacuum tube . . . . μ
amplitude modulated(as noun or adj.). . . AM
atmosphere. . . . . atm
audio-frequency (as adj. only). . . . . . a-f
average . . . . avg
Balance . . . . bal
British thermal unit. . . . . Btu
calorie . . . . cal
centimeter. . . . . .cm
centimeter-gram-second(system). . . . . . cgs
centistokes . . . . .CS
circular-mil (adjective). . . . . . . cir-mil
coefficient . . . . coeff
counter electromotive force . . . . . . .cemf
cubic . . . . .cu
current I
cycles per second . . . . cps
decibel . . . . .db
power in decibels referred to 1 milliwatt.dbm
degree. . . . . deg
degree (angular measure). . . . . °
degree centigrade C
degree Fahrenheit . . . . F
diffused . . . . .diff
diameter . . . . .diam
direct-current (as adj. only) . . . . . . d-c
dissipation factor . . . . . . D.F.or Diss.F
electric. . . . . .elec
electromotive force . . . . emf
ergs/gm-(C) . . . . e/g-c
foot. . . . . .ft
frequency . . . . .freq
frequency modulated (as noun or adj.) . . FM
Germanium . . . . Ge
gram . . . . .gm
gravitational acceleration. . . . . g
henry . . . . h
hermetically sealed . . . . . . H.S.or Herm.S
horsepower. . . . . .hp
hour . . . . .hr
impedance . . . . Z
inch . . . . .in
intermediate-frequency (as adj.). . . . . i-f
Insulation Resistance . . . . .IR
kilocycles per second . . . . .Kc
kilomegacycles . . . . KMc
kilometer . . . . km
kilovolt. . . . . .kv
kilovolt-ampere . . . . kva
kilowatt. . . . . .kw
magnetomotive force . . . . mmf
maximum . . . . max
megacycle . . . . Mc
megavolt-ampere . . . . mva
megawatt. . . . . Mw
microampere . . . . μa
microfarad . . . . μf or mf
micromicrofarad . . . . $\mu\mu$f or pf
micromicron . . . . $\mu\mu$
micron. . . . . μ
microsecond . . . . .μsec
microvolt . . . . .μv
microwatt . . . . .μw
milliampere . . . . ma
millihenry . . . . mh
millimeter . . . . mm
millimicron . . . . mμ
millivolt . . . . mv
minimum . . . . min
minute . . . . mi
ohm (Ω) . . . . spell out
ohm-centimeter. . . . . .ohm-cm
ounce . . . . .oz
pound . . . . .lb
pound per square inch . . . . psi
pound per square inch gauge . . . . .psig
power . . . . pwr
primary . . . . pri
pulse time modulation . . . . PTM
radio-frequency (as adj.) . . . . r-f
recommended . . . . rec
resistance . . . . R
revolutions per minute. . . . . rpm
short-circuit ratio . . . . scr
signal-to-noise ratio . . . . s/n
single side band. . . . . ssb
square. . . . . .sq
standing-wave ratio . . . . swr
superhigh frequency . . . . shf
temperature . . . . temp
thousand. . . . . M
transformer . . . . .Xfmr
transistor . . . . Xsistor
ultrahigh frequency . . . . uhf
very high frequency . . . . vhf
volt V
volt-ampere . . . . va
watt . . . . W
watthour. . . . . whr
yard . . . . .yd

6.0 CONVERSION FACTORS

To permit comparison of data from various sources, reported in a variety of units, it is frequently necessary to convert to a standard set of units. The standard units used in this document are ergs/gm-(C) for electromagnetic radiation and particles/cm^2 for any type of particulate radiation. In many cases, insufficient information is presented to permit an accurate conversion. The values, marked with an asterisk, are approximately correct for hydrocarbons, assuming an average energy of 1 Mev for the radiation. These values should be used with caution and only in cases where more applicable information is not available.

To Convert	To	Multiply By
Rads (for any material)	ergs/gm (of that material)	100
Roentgen	ergs/gm-(C)	87.7
Roentgen	ergs/gm (Tissue)	96.4
Rep	ergs/gm-(C)	84.6
Rep	ergs/gm (Tissue)	93.0
Rad (Tissue)	ergs/gm-(C)	90.9
Rad (water)	ergs/gm-(C)	90.0
*(1) Photons/cm^2	rep	5×10^{-10}
*Rep/hr	n/cm^2-Sec	7.1×10^4
*Rad/hr	n/cm^2-Sec	8.3×10^4
*(2) Rem/hr	n/cm^2-Sec	8.3×10^3
** Photons/cm^2	ergs/gm-(C)	5.7×10^{-8}

* Based on average energy of 1 Mev
(1) For any energy other than 1 Mev, See Figure 2
(2) For any energy other than 1 Mev, See Figure 3
** Based on Co-60 source

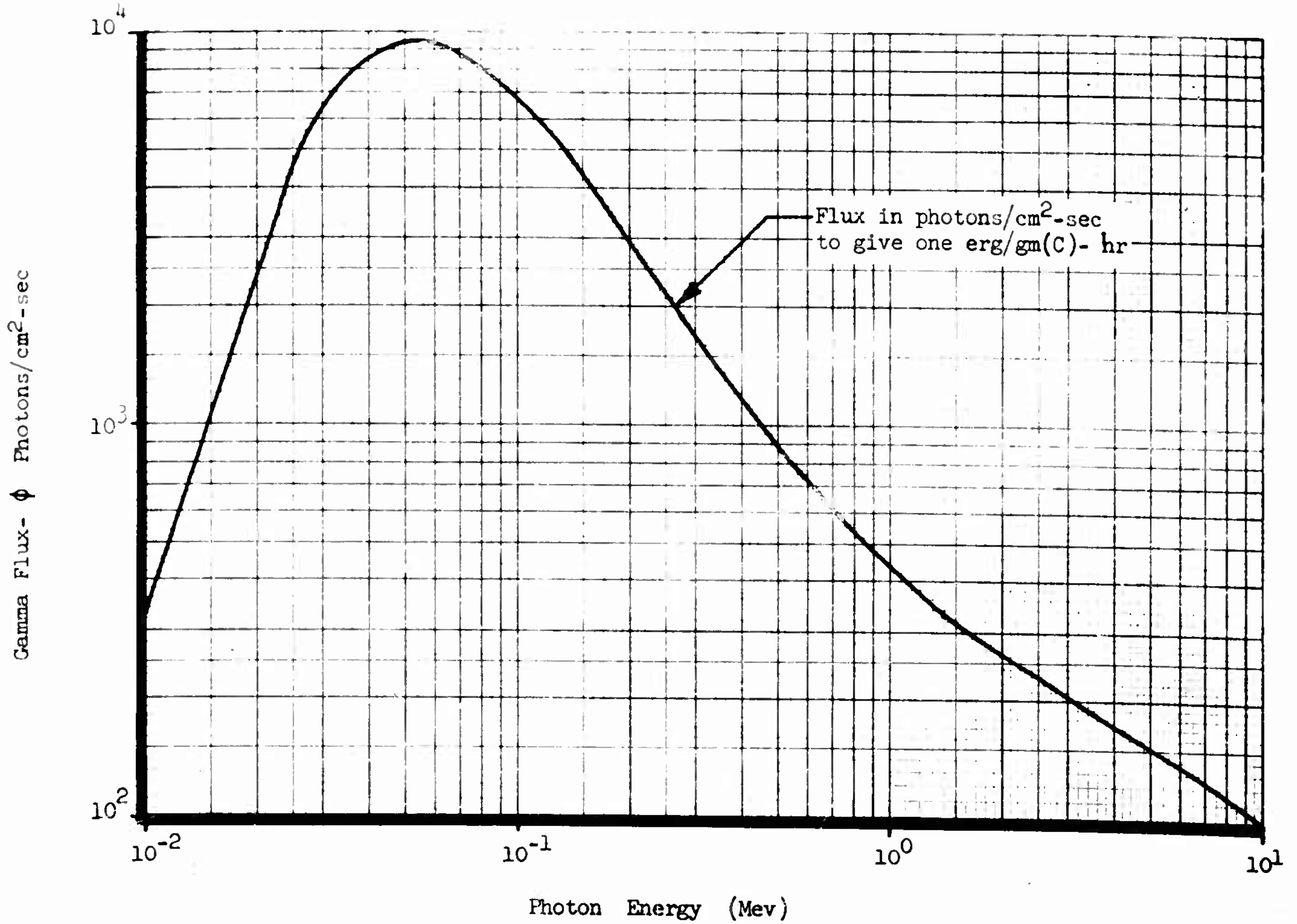

FIGURE 2 NUMBER OF GAMMA RAYS VS. DOSE RATE FOR VARIOUS GAMMA ENERGIES

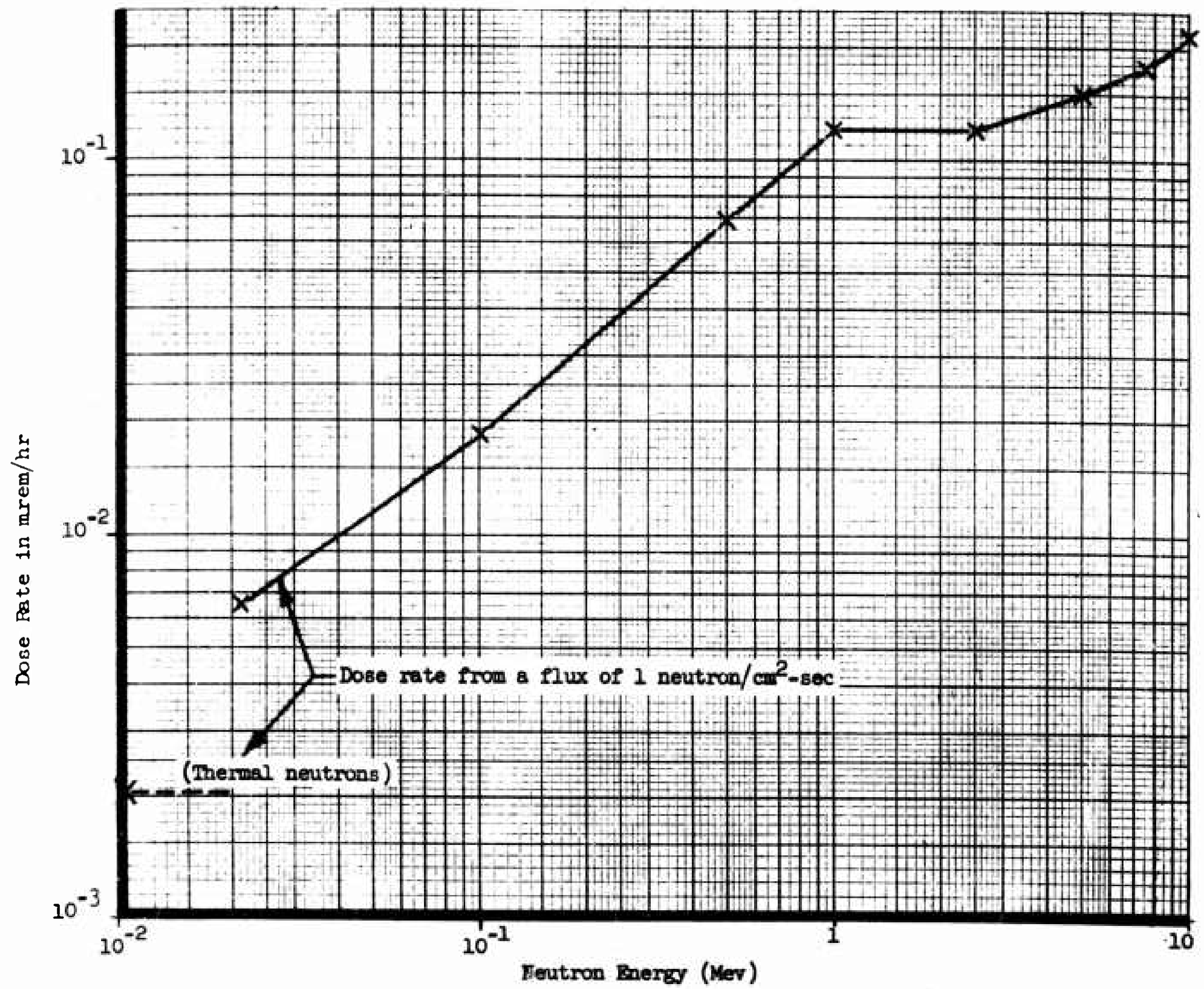

FIGURE 3 CURVE TO CONVERT NEUTRON FLUX TO DOSE RATE

7.0 RADIATION EFFECTS FACILITIES UTILIZED IN GENERATING TEST DATA REFERENCED IN THIS REPORT

7.1 STEADY-STATE REACTOR FACILITIES

Argonne Research Reactor CP-5
Argonne National Laboratory
Argonne, Illinois

R. E. No. 1, 2, 3, 4, 5, 6, 11, 12, 59, 60, 66, 72, 74

Battelle Research Reactor
Battelle Memorial Institute
Columbus, Ohio

R. E. No. 52, 65

Brookhaven Research Reactor
Brookhaven National Laboratory
Upton, New York

R. E. No. 15, 16, 17, 49, 59, 61, 65, 66

Curtiss-Wright Research Reactor
Curtiss-Wright Corporation
Quehanna, Pennsylvania

R. E. No. 28, 75

Ford Nuclear Reactor
University of Michigan
Ann Arbor, Michigan

R. E. No. 35

General Electric Nuclear Test Reactor (GENTR)
Vallecitos Atomic Laboratory
Pleasanton, California

R. E. No. 10, 32, 36, 53

Georgia Nuclear Laboratories Radiation Effects Reactor (GNL)
Lockheed-Georgia Company
Marietta, Georgia

R. E. No. 45, 54

Ground Test Reactor (GTR)
General Dynamics Corporation
Fort Worth, Texas

R. E. No. 9, 11, 12, 13, 21, 22, 23, 24, 25, 26, 30, 31, 34, 37, 38, 39, 40, 41, 44, 46, 48, 50, 51, 62, 69

Materials Testing Reactor (MTR)
National Reactor Testing Station
Idaho Falls, Idaho

R. E. No. 42, 56, 58

MTR & ETR Spent Fuel Radiation Irradiation Facility
Idaho Falls, Idaho

R. E. No. 46, 64

MIT Research Reactor
Massachusetts Institute of Technology
Cambridge, Massachusetts

R. E. No. 75

Oak Ridge Research Reactor
Oak Ridge National Laboratory
Oak Ridge, Tennessee

R. E. No. 58

Penn St. Research Reactor
Penn St. University
University Park, Pennsylvania

R. E. No. 16, 17, 18, 19, 75

7.2 **GAMMA SOURCES AND PARTICLE ACCELERATORS**

Admiral Cobalt-60 Source
Admiral Corporation
Chicago, Illinois

R. E. No. 1, 2, 3, 6, 60, 70, 74

Argonne Cyclotron and Linear Accelerator Facility
Argonne National Laboratory
Argonne, Illinois

R. E. No. 27

Argonne High Level Gamma Irradiation Facility
Argonne National Laboratory
Argonne, Illinois

R. E. No. 8, 33, 71

Armour Research Ion Bombardment Chamber
Armour Research Foundation
Chicago, Illinois

R. E. No. 7

Battelle Gamma-Irradiation Facility
Battelle Memorial Institute
Columbus, Ohio

R. E. No. 14

Bell Telephone Laboratories Cobalt-60 Gamma Cell
New York, New York

R. E. No. 17

Brookhaven Gamma Irradiation Facility
Brookhaven National Laboratory
Upton, New York

R. E. No. 19

Cook Technological Gamma Facility
Cook Electric Company
Morton Grove, Illinois

R. E. No. 47

General Atomics 45 Mev Linear Accelerator
General Dynamics Corporation
San Diego, California

R. E. No. 213

Shell Van de Graaff Accelerator
Shell Development Company

R. E. No. 68

University of Minnesota Gamma-Irradiation Facility
University of Minnesota

R. E. No. 33

Van de Graaff (WNYRC)
Western New York Research Center, Inc.
Buffalo, New York

R. E. No. 8

WADD Cobalt-60 Source
Wright-Patterson Air Force Base, Ohio

R. E. No. 11, 12, 55, 57, 73

Miscellaneous Cobalt-60 Sources

R. E. No. 63

7.3 PULSED REACTORS

DOFL TRIGA Mark F
Harry Diamond Laboratories
Washington, D. C.

R. E. No. 202

General Atomics TRIGA Mark F
General Dynamics Corporation
Torrey Pines, California

R. E. No. 207

Godiva
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

R. E. No. 200, 201, 203, 205, 209, 210, 216

KEWB (Kinetic Experiments on Water Boilers)
National Reactor Testing Station
Idaho Falls, Idaho

R. E. No. 215

Kukla
Lawrence Radiation Laboratory
Livermore, California

R. E. No. 208

SPRF (Sandia Pulsed Reactor Facility)
Sandia Corporation
Albuquerque, New Mexico

R. E. No. 11, 12, 30, 204, 206, 212, 214

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